



88047907

UNITED STATES
DEPARTMENT OF THE INTERIOR

FINAL
ENVIRONMENTAL STATEMENT
Volume 1 of 5

Proposed
1975 OUTER CONTINENTAL SHELF
OIL AND GAS GENERAL LEASE SALE
OFFSHORE SOUTHERN CALIFORNIA
(O.C.S. Sale No. 35)



Prepared by the
BUREAU OF LAND MANAGEMENT

Gert Berklund

Director

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Summary

() Draft (X) Final Environmental Statement
Department of the Interior, Bureau of Land Management
Pacific OCS Office

1. Proposed Oil and Gas Lease Sale, Outer Continental Shelf
Southern California
(X) Administrative () Legislative Action
2. Two hundred ninety-seven tracts (1,554,815 acres) of OCS lands are proposed for leasing action. The tracts are located in the following five general areas offshore southern California: Santa Rosa-Cortes South (291,520 acres); Santa Monica Bay (163,662 acres); Santa Barbara-Santa Catalina (180,352 acres); San Pedro Bay (279,921 acres); and Santa Rosa-Cortes South (639,360 acres). The tracts are situated in water depths that range from approximately 5 meters to 750 meters. If implemented, this sale is tentatively scheduled to be held in the fall of 1975.
3. All tracts offered pose some degree of pollution risk to the environment. The risk potential is related to adverse effects on the environment and other resource uses which may result principally from accidental or chronic oil spillage. If platform development is permitted, the development of many of the proposed tracts in the Santa Monica and San Pedro Bay areas may cause degradation of the visual environment. If development is permitted in close proximity to pinnipeds and seabird rookeries they may be disturbed sufficiently to abandon their breeding grounds. Each tract offered has received a proximity evaluation using a matrix technique to identify significant environmental impacts should leasing and subsequent oil and gas exploration and production ensue.
4. Alternatives considered:
 - A. Hold the Sale in Modified Form
In order to avoid various impacts of the sale as proposed, modifications of the proposal are considered including offering one or more of the five major tract blocks, offering other areas in the southern California Borderland, deleting certain tracts to protect State oil sanctuaries and Areas of Special Biological Significance, establishing buffer zones within which activity would be restricted in order to protect pinnipeds and seabird rookeries and preserve the esthetic qualities of the coastal view, and deleting tracts or deferring their offering until deepwater development technology is proven.

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B. Withdraw the Sale

The alternative of withdrawing the sale is considered with regard to substitutability of conservation measures, other energy sources both conventional and exotic, and combinations of these alternatives.

C. Delay Sale

Consideration is given to delaying the proposed sale until new technology is available to provide increased environmental protection, until studies concerning environmental impacts of offshore minerals development are completed, until onshore land use and growth plans are completed, and until implementation of recommendations on OCS Operating Orders and Regulations and further review of regulations are completed.

D. Alternative OCS Leasing Areas

The alternative of leasing in other areas of the OCS is considered.

E. Alternatives Within the Proposed Action

The alternatives of government exploratory drilling before leasing and a formal pause between exploration and development phases are considered.

5. Comments have been requested from the following:

- * Environmental Protection Agency
- * Department of Commerce
 - National Oceanic and Atmospheric Administration
- * Department of Defense
- * Department of Transportation
 - U.S. Coast Guard

* Comments Received.

- * Federal Energy Administration
- * Energy Research and Development Administration
 - Federal Power Commission
- * State of California
 - Director of Planning and Research
 - Office of the Governor
- Department of the Interior
 - *U.S. Fish and Wildlife Service
 - *Bureau of Outdoor Recreation
 - *Bureau of Mines
 - *Geological Survey
 - *National Park Service

6. Draft Statement made available to Council on Environmental Quality and the public on February 21, 1975.
7. Final Statement made available to Council on Environmental Quality and the Public on August , 1975.

* Comments Received.

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Errata Sheets

I. DESCRIPTION OF PROPOSAL

A. Location and Resources

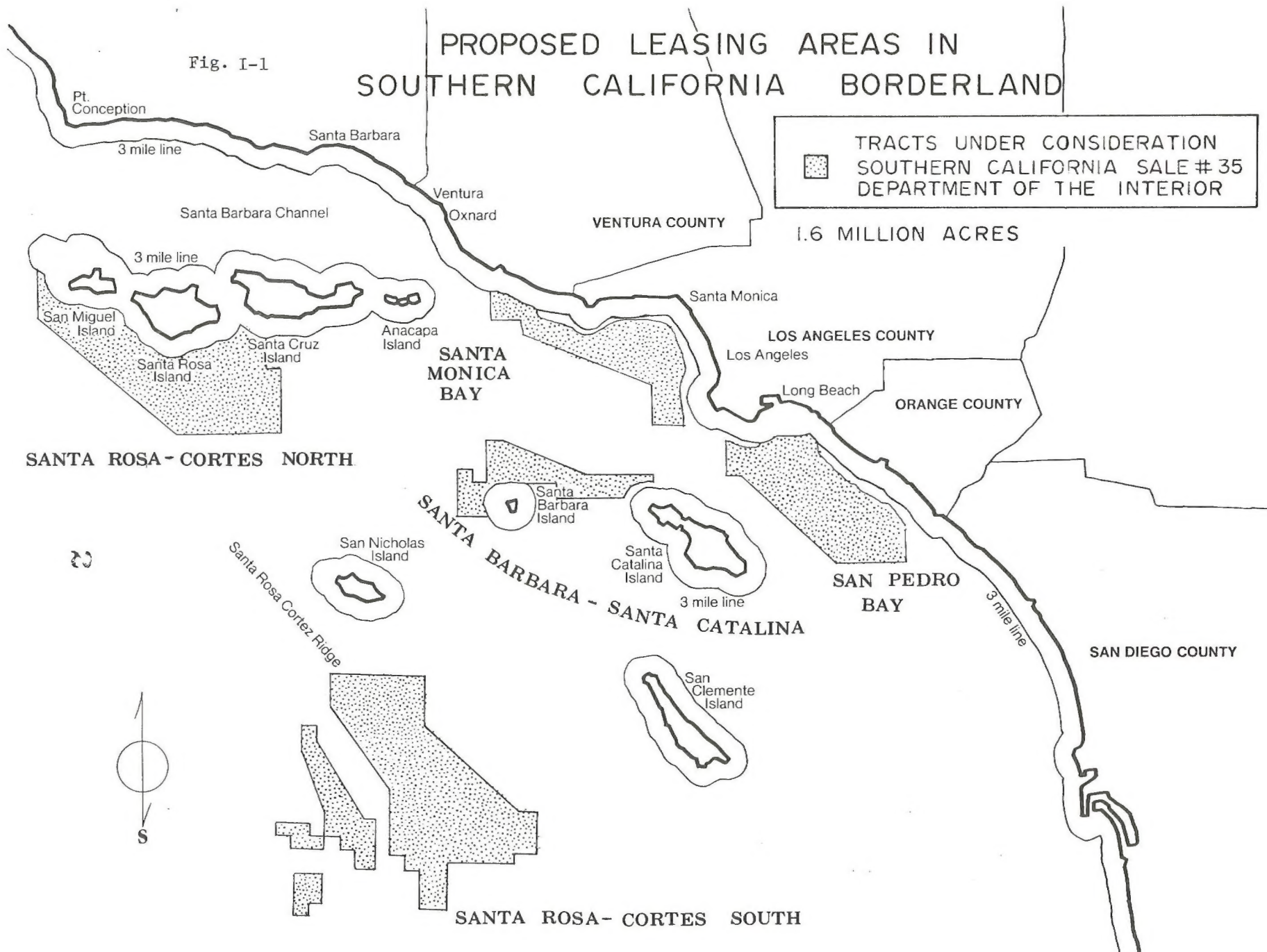
The proposed federal action under consideration is the leasing of 297 tracts in offshore Southern California. These tracts encompass an area of 1.55 million acres and are located beyond the three mile limit. The proposed sale would be held in accordance with Section 8 of the Outer Continental Shelf (OCS) Lands Act (76 Stat. 462; 43 USC, Sec. 1337). See Figure I-1 and also Graphic 1 in Volume 5 of this statement for the location of these tracts in the Southern California Borderland.

According to the U. S. Geological Survey (USGS), the potential recoverable resources within the proposed lease area total approximately 1.6 - 2.7 billion barrels of oil, and 2.4 - 4.8 trillion cubic feet of gas. A breakdown by area is as follows:

<u>Area</u>	<u>Million BBL Oil</u>	<u>Billion Ft³ Gas</u>	<u>Acreage ^{1/} (Estimated)</u>
San Pedro Bay	709-946	602-821	280,000
Santa Monica Bay	329-440	479-711	163,700
Santa-Rosa Cortes (North)	242-431	603-1108	291,500
Santa-Rosa Cortes (South)	239-660	613-1785	639,400
Santa Barbara-Santa Catalina	67-219	103-342	180,400
Totals	1,586-2,696	2,400-4,767	1,555,000

Western Oil and Gas Association (WOGA) estimated that recoverable resources from the area identified in the call for nominations could

1/ Bureau of Land Management



vary from 6 to 19 billion barrels of oil with a gas production ratio of 2,000 cubic feet (2 MCF) per barrel of oil. Their most probable estimate was 14 billion barrels of oil and 28 trillion cubic feet of gas. WOGA recommended no changes in these estimates after identification of the proposed sale area. For the sale area of 1.55 million acres these resources have been converted to a production schedule by WOGA, beginning with 269,000 bbls/day in 1981 increasing to 762,000 bbls/day in 1987 and culminating in over a million bbls/day by the year 2000. For purposes of analysis and computing oil spill estimates, the figure of 14 billion barrels was used as the high range of recoverable resource in this statement, while the USGS figure of 1.6 billion barrels was used as the low range.

B. Legal and Administrative Background

1. Authority and Leasing Objectives

In 1953, the Outer Continental Shelf (OCS) Lands Act (67 Stat. 462) established Federal jurisdiction over the submerged lands of the continental shelf seaward of the state boundaries. The Act charged the Secretary of the Interior with the responsibility for the administration of the mineral exploration and development on the OCS. It also empowered the Secretary to formulate regulations so that the provisions of the Act might be met.

Subsequent to the passage of the OCS Lands Act of 1953, the Secretary of the Interior designated the Bureau of Land Management (BLM) as the administrative agency for leasing submerged federal lands, and the Geological Survey for supervising operations. The Department formulated three major goals for the comprehensive management program for marine minerals. These are:

- (1) The orderly development of the marine mineral resources to meet the energy demands of the nation.
- (2) The protection of the marine and coastal environment.
- (3) The receipt of a fair return for the leased mineral resources.

These leasing objectives are based on legislative mandates as explained below.

(1) Orderly resource development is based on the OCS Lands Act which gives the Secretary the authority, in order to meet the urgent demand for oil and gas, to grant leases to the highest qualified bidder(s) on the basis of sealed competitive bids.

(2) Protection of the marine and coastal environment is a direct outgrowth of the National Environmental Policy Act of 1969. This act requires that all Federal agencies shall utilize a systematic, interdisciplinary approach which will insure the integrated use of the natural and social sciences in any planning and decision-making which may have an impact on man's environment. The products of BLM and USGS efforts in this direction are Environmental Impact Statements (EIS), establishment of Environmental Assessment Teams and contract studies designed to identify and characterize different types of environments and the problems that they face. The USGS also provides geological and geophysical evaluation of selected tracts.

(3) Receipt of fair market value has basis in two separate mandates. United States Code 31, Sec. 483 (a) obligates the Federal Government to obtain a fair return for public lands that are sold or leased. This is further implemented within the Executive Branch by Bureau of the Budget Circular A-25.

2. Federal and State Leasing History

There have been three offshore oil and gas lease sales on Federal areas of the submerged lands offshore California, two in the Santa Barbara Channel and one offshore northern California. The first OCS lease sale in the California areas was held on May 14, 1963, the second on December 15, 1966, and the last on February 6, 1968. The total bonuses collected from these sales were in excess of \$636 million and resulted in the leasing of 678,121 acres.

State leasing history for offshore oil and gas development commenced with the Tidelands Leasing Act of 1921 (Chapter 303, Statutes of 1921). The act provided for leasing of state tidelands for commercial discoveries of oil and also a royalty system for the state. Although the first offshore production in California as well as in the United States started in 1896 as an extension of the Summerfield Oil Field in Santa Barbara County, the 400 wells drilled from this activity were under lease from private landowners and no royalties were paid to the state. Of these wells 220 could be classified as offshore.

Subsequent to tideland discoveries in Huntington Beach in 1933, the State Lands Act of 1938 created the States Lands Commission with the power to administer, control and lease all ungranted tidelands and submerged lands owned by the state. After a court test, one of their decisions resulted in the construction of the first artificial island, "Monterey", in 1954 to develop the Belmont offshore field one and one-half miles from Seal Beach. Intervening leasing activity included municipal leasing on granted tidelands by Long Beach in 1939 (Wilmington field) and Newport Beach in 1957 (West Newport field).

In 1955 the California Legislature adopted the Cunningham-Shell Tidelands Act which restricted state leasing to areas of known potential in central and Southern California. Certain scenic lands along the coasts of Los Angeles, Santa Barbara and San Luis Obispo Counties and the islands of San Clemente and Santa Catalina were excluded from leasing except when subjected to possible drainage from wells drilled upon adjacent lands owned by others. The act also provided for the construction of drilling platforms. The first permanent drilling platform, "Hazel", was built in 1958 about two miles offshore from Summerland.

Following the 1969 blowout of Platform A in the Santa Barbara Channel, all new drilling on state-owned tidelands was banned subject to State Lands Commission review. Drilling into the tidelands from offshore sites was permitted shortly thereafter but the only new drilling from offshore sites was two wells from Island Esther in 1971. The Commission's offshore jurisdiction extends three nautical miles seaward of the shoreline, including the shorelines of the Channel Islands (see Figure I-1). Currently there are 131 state-issued oil and gas leases in effect, representing 165, 157 acres of tide and submerged lands undergoing oil and gas development. About 800 thousand acres of mineral rights are controlled by private and municipal concerns upon which 215 new wells have been drilled from offshore sites since the 1969 blowout.

3. Federal Government Action Following Santa Barbara Oil Spill

After the blowout and oil spill on Lease OCS-P 0241, the Secretary of the Interior ordered the suspension of all drilling and

production on Federal leases in the Santa Barbara Channel. These suspensions affected only six leases on which drilling and production operations were in progress at the time. The DuBridge Panel, appointed by the President, and Department of the Interior Task Forces commenced scientific and engineering studies of the Channel.

The DuBridge Panel recommended that the producing reservoirs in the Dos Cuadras Offshore field should be depleted as rapidly as possible, consistent with safe practices. Additional drilling and production operations on Lease OCS-P 0241 were authorized in June 1969. The resulting fluid withdrawal decreased pressures in the reservoirs and thus diminished the amount of the oil reaching the ocean floor from overpressured reservoir sands. The reduction of pressures in deeper pay zones may or may not effect pressures in Zones B, C, and D reservoir sands. In August 1969, a development platform was authorized for Lease OCS-P 0240 to facilitate pressure reduction in the eastern portion of the Dos Cuadras Offshore field.

In addition to the suspension of drilling and production operations on six leases in the Santa Barbara Channel, the Department initiated a safety clearance review of the remaining leases in the Santa Barbara Channel not then in a drilling or production status. Following a thorough review on a lease-by-lease basis, safety clearances were given and operations were permitted to proceed on these leases. Moreover, specific OCS operating Orders for the Pacific area were issued on June 1, 1971. (See Appendix 5 for these Orders). All OCS operations must comply with these operating Orders as well as appropriate Federal Regulations.

4. California Coastal Zone Conservation Act of 1972

As a result of the Santa Barbara oil spill and the need to protect the coast, the people of California passed Proposition 20 on November 7, 1972, now known as the Coastal Zone Conservation Act of 1972. Earlier in 1972 Congress passed the Federal Coastal Zone Management Act directing the states to develop plans for coastal zone management. The act provides for partial federal funding to implement this process. Following adoption of coastal plans by the states, the Federal Government will review the plans for adequacy and compliance with national interests in the coastal zone.

Section 27001 of the California Act summarizes its intent: "The people of the state of California thereby find and declare that the California coastal zone is a distinct and valuable natural resource belonging to all of the people and existing as a delicately balanced ecosystem; that the permanent protection of the remaining natural and scenic resources of the coastal zone is a paramount concern to present and future residents of the state and nation; that in order to promote the public safety, health, and welfare, and to protect public and private property, wildlife, marine fisheries, and other ocean resources, and the natural environment, it is necessary to preserve the ecological balance of the coastal zone and prevent its further deterioration and destruction; that it is the policy of the state to preserve, protect, and, where possible, to restore the resources of the coastal zone for the enjoyment of the current and succeeding generations."

The complete text of the Act is in Appendix 25.

With the passage of this proposition the California Coastal Zone Conservation Commissions were created. The commissions - one state-wide and six regional - were directed to prepare a plan for the future of the California coast, and to regulate coastal development temporarily, while the plan was being prepared.

"The preliminary coastal plan has now been published and public hearings are being conducted to seek the people's views on the plan itself, with its recommendations for use and protection of the California coast; and the most effective governmental means of carrying out the Coastal Plan" (M. B. Lane, Chairman of the Commission). After the public hearings are completed the Coastal Commission will adopt their final recommendations this summer and fall, for presentation to the governor and the legislature in December 1975.

The preliminary Coastal Plan recommends basic rules to govern use and protection of the coastal zone now and in the future, and the plan will, in its final version recommend governmental means to enforce its policies and keep them current as circumstances change. The following is a brief summary of the Preliminary Coastal Plan as presented in the pamphlet, In Brief: Preliminary Coastal Plan, issued by the California Coastal Zone Conservation Commission:

Major Findings and Recommendations

The essence of the Plan is that the coast should be treated not as ordinary real estate but as a unique place, where conservation and special kinds of development should have priority. The Plan's foundation is the fact that coastal resources are limited, and that meeting human needs while protecting the coast will require policies such as

the following:

Public Use of the Coast. Public access to appropriate coastal areas should be provided. Coastal developments that serve the public-- such as campgrounds, resorts, hotels and motels, rental housing, etc.-- should have priority over coastal developments that are essentially private, such as typical residential developments.

Wetlands. Coastal marshes and other wetlands, many of which have been filled and diked in past years, should be protected from further destruction and restored where possible.

Agricultural Lands. Coastal lands suitable for agricultural production should be kept in agriculture, and tax policies should be changed to reduce pressures to convert such land to urban development.

Coastal Streams. Free-flowing coastal streams should be protected, because they are necessary for the migratory fish caught by commercial and sport fishermen and because they supply sand for coastal beaches.

Air Quality. Potentially polluting development in critical air quality areas should be allowed only if designed to prevent any significant degradation of coastal air quality.

Energy. The use of increasing amounts of coastal land and water to meet energy needs should be reduced by a vigorous program of energy conservation. Energy installations allowed on the coast must be subject to stringent environmental safeguards.

Transportation. Public transit should receive priority over roadway construction in urban areas, to reduce the need for coastal parking lots and major highway programs, to conserve energy, and to improve coastal air quality.

Hazards to Development. Development should only be permitted in hazardous areas, such as those subject to beach or cliff erosion, landslides, earthquakes, and flooding, if adequate engineering can reduce the hazards to acceptable levels.

Public Recreation. Public recreation should have the highest priority in suitable areas of the coast, and legal rights of the public to have access to publicly owned tidelands should be vigorously enforced. Public use of coastal lands and waters should be consistent with natural resource protection.

Concentrated Development. Where substantial new development would harm coastal resources and restrict public access to the oceanfront, new development should be channeled to the inland parts of coastal cities and to other inland areas. Public investment in roadways, water systems, sewer systems, and other installations should be designed to concentrate development in existing communities (consistent with their ability to absorb it) and thus to end wasteful, sprawling development along the coast.

Cumulative Impact of Development. In areas where a few developments would not adversely affect coastal resources, but where the cumulative effect of many such developments over several years could be harmful, specific, detailed plans anticipating all such development should be prepared.

Coastal Viewshed and Scenic Areas. Designs for all development should be compatible with scenic areas and not be permitted to degrade areas of high scenic value.

Special Coastal Communities and Neighborhoods. New developments should be consistent with the unique cultural, historical, architectural, and aesthetic qualities of particular coastal communities and neighborhoods.

Highway 1. Highway 1 in rural areas should remain a two-lane highway primarily for recreational travel. A system of budgeting the remaining road capacity should be prepared and the remaining capacity should be allocated so that private residential and commercial development will not limit public recreational travel.

Public Ownership on Shoreline. The long-term goal (possibly 50 years away) of coastal planning and development should be public ownership of a strip of land paralleling the coast, except for ports, urban areas, etc. High priority for public land acquisition should be given to open space on urban waterfronts and to small lots in scattered ownership if their development would impede public access or mar coastal views.

Governmental Actions. The plans and operations of many Federal, state, and local agencies should be reviewed to better protect coastal resources.

Carrying Out the Plan

Any plan dealing with controversial matters will have lasting value only if it can be enforced. The California Coastal Act, therefore, requires that the Coastal Plan contain "recommendations for the governmental policies and powers required to implement the (plan) including the organization and authority of the governmental agency or agencies which should assume permanent responsibility for its imple-

mentation."

There are several ways, some more effective than others, by which the Coastal Plan can be carried out. The Preliminary Plan reaches no conclusions as to which way would be best. But after public hearings this spring, and after further review by the State and Regional Commissions, specific recommendations for carrying out the Coastal Plan will be made in the Commissions' final report to the Governor and the Legislature.

C. Tract Selection Process

The tract selection process is one of the steps used by the Department in attaining its objectives of orderly resource development, protection of the environment, and receipt of fair market value.

The mechanics involve an identification, by the Department of the Interior, of a broad potential lease area, which in this case was offshore Southern California. In January 1974, a Call for Nominations requested industry to nominate by tracts 1/, areas they would like to see offered for lease. The nominated areas were then analyzed by both the Bureau of Land Management (BLM) and U.S. Geological Survey (USGS) to make an initial determination of selected tracts to offer in the event of a sale. The nominated areas were analyzed on the basis of:

- 1) Interest shown (nominations);
- 2) regional geology and potential reserves; and
- 3) environmental as well as other considerations.

1/ Most tracts are 9 square miles (5,760 acres).

1. Nominations and Leasing History

The Department's call for nominations in Southern California resulted in approximately 6.8 million acres being nominated by 17 companies out of 7.7 million acres offered. During the tract selection process the 6.8 million acres was reduced to approximately 1,555,000 acres (297 tracts). Interest shown as determined by the number of nominations received by each tract was an important factor in the tract selection process. A more complete discussion of how the 7.7 million acres included in the call for nominations was reduced to the 1.55 million acres for the proposed lease sale is located in Volume II, Section VIII.A.2. This is the first call for nominations in this specific area. No leasing history exists for any of the selected tracts.

2. Geology

On March 22, 1974, the Bureau of Land Management (BLM) in Los Angeles forwarded their initial tract selection preferences to USGS. At that time BLM requested a complete geologic and geophysical evaluation by USGS of each prospective tract. This evaluation was completed one month later and the review by USGS covered the following:

- 1) Resource Estimates
- 2) Geological Information
- 3) Geophysical Data
- 4) Actions Planned to Fill Data Gaps
- 5) Deep Water Technology
- 6) Problems Associated with Exploration and Development
- 7) Availability - Material, Equipment, Personnel and Capital
- 8) Drainage - Adjacent State Lands

In the majority of cases the USGS evaluation coincided with the rec-

ommendations determined by the initial analysis of nominations.

3. Environmental Considerations

The BLM-Pacific OCS Office has the responsibility of assessing the overall environmental impacts which may occur from the proposed leasing operations. Preliminary resource reports on the environment were prepared for the overall sale area by utilizing a combination of an in-house study and review of a study contracted with the Southern California Ocean Studies Consortium (a team of five California State universities). Both studies included an examination of the physical, biological, economic, and social resources within Southern California and its offshore borderland. An environmental report was then prepared and submitted to the BLM manager prior to actual tract selection recommendation. The report was prepared by the Environmental Assessment Team for the purpose of ensuring that all potential tracts had been fully reviewed for potential environmental hazards.

Specifically, the tract selection process included a detailed analysis of all areas where possible environmental degradation might occur as a result of oil exploration and development. The Southern California environmental resource categories evaluated included:

1. Geology (bottom sediments and paleontology)
2. General climatology and seasonal weather patterns (visibility, winds, temperature, inversions, storms, and precipitation)
3. Physical oceanography (sea temperatures, salinity, surface circulation including currents, waves and swells and tides)
4. On and offshore outdoor recreation
5. Archeological and historical sites
6. Land use
7. Socio-economics (population, employment, income and economic characteristics, agriculture, and refining and processing facilities)
8. Transportation network

9. Air quality
10. Physical hazards (ocean dumping areas, military activities, existing pollution factors, undersea cables, ship transit lanes, ship wrecks and harbor areas)
11. Terrestrial vegetation
12. Kelp beds
13. Phytoplankton
14. Benthos
15. Intertidal communities
16. Rare and endangered species
17. Areas of unique biological significance and marine life preserves
18. Terrestrial birds and wildlife
19. Marine and shorebirds
20. Marine mammals
21. Commercial and sport shellfish
22. Finfish, including commercial finfish areas
23. Aesthetics.

The above basic information was then interpreted (using both written documentation and map overlays) in regard to the potential impact on, or hazard to, the individual resource from offshore drilling and development, pipeline construction and oil spillage. From these interpretations "potential environmental hazard zones" were developed for use in the tract selection process. This type of procedure was also used in evaluating other considerations as well.

4. Other Considerations

Other areas which were researched and evaluated, and affected the tract selection process were:

1. Use conflicts (defense warning zones, etc.).
2. Policy guidelines.
3. Deepwater tracts 1/ and technology.
4. Possible drainage of reserves from state lands.
5. United States-Mexico offshore boundary. The offshore boundary between the two countries is in dispute. The U. S. considers it to be a median line, or a line formed by points that are everywhere equidistant from points onshore, including islands. The Mexican

1/ Almost 1 million acres or 64 percent of the acreage selected is in water depths over 250 meters (820 feet).

position views it as the seaward extension of the present U. S. -Mexican border. In either case, there are no tracts in the proposed leasing area affected by either an offshore extension of the onshore boundary or the median line.

D. Activity Resulting from this Proposal in the Southern California Borderland

1. Commercial Activity

The amount of commercial activity that may be generated in the Southern California borderland as a result of this proposal is dependent on many variables. Chief among them would be the availability of capital, manpower, equipment and the amount of proven recoverable resources. Table I-1 summarizes a low and high range of construction activity that may reasonably be expected to occur if the proposed sale is held.

In addition some improvements in existing harbor facilities is anticipated.

The intensity and time frame for development of the offshore area is dependent upon several variables, such as the number of discoveries and availability of facilities to develop these resources.

The exploratory drilling phase can be expected to continue for a period of five years. As a result of discoveries, there will be an overlapping of the development phase with the installation of platforms and pipelines. Shallow water areas in the Santa Monica and San Pedro basins are expected to provide the initial production during the early stages of development. An estimated 30 to 60 percent of the recoverable resource (oil and gas) may lie in these two areas. As support and supply facilities are established, exploratory drilling could extend to areas further from shore, possibly in the vicinity of

Table I-1

Acreage and Estimated Construction Activity Required to Develop
Hydrocarbon Resources Within the Proposed Sale Area

	<u>This Proposed Sale</u>
a. Acres (millions)	1.55
b. Wells	
--producing	800 - 4975
--exploratory	60 - 480
c. Platforms	14 - 60
d. Miles of Pipeline Corridor	150 - 900
e. Terminal/Storage Facilities (onshore <u>1</u> / & offshore)	2 - 15
f. Support/Supply Facilities (onshore) <u>1</u> /	1 - 3
g. Pipeline Terminals	1 - 3
h. Floating Processors	0 - 7
i. Fleet	0 - 35

1/ Facility estimates all for mainland areas only. Channel Island development was considered in a report published by Western Oil and Gas Association but development is not anticipated at this time.

Table I-1 (continued)

Estimated Annual Crude Oil Transportation

Estimated to be transported by tankers	8 - 72 million bbls.
Estimated to be transported by pipeline	28 - 288 million bbls.
Total Annual Production	36 - 360 million bbls.

Estimated Volume of Commercial Mud and Drill Cuttings (Assumes 860-5455 wells at a depth of 8,000 feet)

Drill Cuttings =	0.5 - 3.0 million tons
Mud Chemicals	
Discharge =	14.0 - 84.0 thousand tons

Estimated Volume of Produced Brine for the Proposed Lease Sale Area (Assumes a 50% water cut)^{2/}

1.5 - 14 billion barrels

Estimated Total Land Use Requirements for Onshore Facilities
100 - 200 acres

Estimated Pipeline Burial Disturbance (where buried)^{3/}
4,000 to 8,000 cubic yards per mile

^{2/} U.S. Geological Survey estimate.

^{3/} In most cases water depth will preclude burial.

the Santa Barbara/Santa Catalina Islands and Santa Rosa-Cortes Ridge areas.

Production platforms are expected to be utilized in water depths up to 1200 feet. In deeper water, subsea completions would probably be used. In the Santa Monica and/or San Pedro Bay areas, subsea completions may be opted for in near shore areas for visual aesthetic reasons.

The time frame for activity would be expected to cover a span of approximately 60 or more years as development in some deep water areas could still be underway by the year 2000. Exploration and development activities would be expected to peak in shallow water areas between 1985 and 1990 and in deep water areas as much as 20 years later. Production activity could continue through 2040 depending on the amount of the recoverable resource in deep water tracts. Platform construction is assumed at two per year. In the event of a large discovery final installation would be after the year 2005.

The highest level of employment is anticipated to take place between 1985 and 1990 when an employment level of 3,000 to 15,000 people is anticipated depending on the level of development.

California OCS development would not result in any new refineries. The need for additional capacity would be in response to consumer demand, rather than to new supplies which may flow from offshore oil and gas fields. If demand does not grow, OCS oil and gas will simply replace imported oil and gas. All projections, however, indicate

that demand will continue to grow, but at a slower rate (3.0%). Federal Energy Administration's Project Independence Report, November 1974 estimates energy demand to increase at a level of between 2.7 to 3.2 percent annually between 1972-1985. Higher oil and gas prices and conservation efforts are responsible for the slower rate. Current estimates of growth of consumer demand indicate that refinery capacity in California will have to be increased by approximately 35% by 1985 to meet demand. If this sale takes place, production is expected to flow to existing facilities in the Los Angeles/Long Beach area.

2. Baseline Studies

The Bureau of Land Management (BLM) has initiated an environmental studies program on the outer continental shelf (OCS) to aid in evaluating marine resource potential and impacts resulting from development of marine resources. The objectives of the OCS environmental studies program are as follows:

- a) Provide information about the OCS environment that will enable the Department and BLM to make sound management decisions regarding the development of mineral resources,
- b) Develop a basis for predicting the impacts of oil and gas exploration and development on the marine environment,
- c) Establish a basis for prediction of impacts of OCS oil and gas activities in frontier areas, and
- d) Provide impact data that would result in modification of leasing regulations, operating regulations, or operating orders if needed to lessen or mitigate environmental impacts.

BLM seeks to attain these objectives by:

- a) Establishing environmental baseline studies in selected OCS regions where oil/gas exploration is anticipated based on promising resource potential,
- b) Conducting environmental monitoring during oil/gas exploration and production to detect changes in the marine environment, and
- c) Conducting special studies such as spill trajectory studies, socio-economic impacts, toxicity studies, etc.

The BLM is presently engaged in conducting a major baseline study of the proposed OCS lease area. Included in this program is a Marine Mammal-Bird Baseline Study which is currently being conducted by the University of California at Santa Cruz and U. C. Irvine. This study is for a minimum of one to two years and covers the following major topics:

- I. Status of breeding biology of both marine mammals and birds.
- II. Determination of the areas of foraging for individual colonies of sea birds.
- III. Determination of the distribution and populations of marine birds and mammals.
 - a. Aerial surveys
 - b. Shipboard surveys
 - c. Color marking of birds
 - d. Radio tracking of birds and mammals
 - e. Freeze branding of mammals
 - f. Spaghetti tagging mammals
- IV. Determination of the seasonal migration routes of both marine birds and mammals.
- V. Conduct beached animal surveys on both marine birds and mammals.

- VI. Conduct island surveys of breeding populations of both marine birds and mammals.
- VII. Analyze parasites and foods of collected specimens of both birds and mammals.

The other major portion of the baseline program covers the biological, chemical and physical aspects of the existing marine environment, and includes the following:

A. Water Column Sampling

- 1) Particulates and dissolved organic carbon
- 2) Dissolved high molecular weight hydrocarbons
- 3) Low molecular weight hydrocarbons
- 4) Particulates for trace metals
- 5) Physical parameters (temperature, salinity, dissolved oxygen, etc.)

B. Box Core Samples

- 1) Microfauna
- 2) Macrofauna
- 3) Chemical analysis
 - a. trace metals
 - b. hydrocarbons

C. Trawls and/or Dredges

- 1) epifauna
- 2) infauna
- 3) hydrocarbon analysis
- 4) photograph each box core area

D. Intertidal Sampling

- 1) Areas
 - a. Sandy beaches
 - b. Rocky intertidal
 - c. Sloughs
- 2) Undisturbed Sampling
 - a. Photographic survey of transect line
 - b. Descriptive record
- 3) Disturbed Sampling
 - a. Physical collection of biota
- 4) Kelp Bed Surveys
 - a. Aerial flyovers quarterly

E. Laboratory Analysis

- 1) Water Column Samples
 - a. high molecular weight hydrocarbons
 - b. Particulate and dissolved organic carbon
 - c. Trace metal analysis
- 2) Box Cores (biological)
 - a. Faunal identification
 - b. Community structure analysis
 - c. Foraminifera identification and live-dead ratios
- 3) Sediment Analysis
 - a. Standard sediment parameters
 - b. Clay mineralogy analysis
- 4) Chemistry
 - a. High molecular weight hydrocarbons
 - b. Trace metals
- 5) Benthos/Sediment
 - a. Faunal identification
 - b. Community Structure Analysis
 - c. Foraminifera analysis
 - d. Sediment analysis
 - e. Chemical analysis

These studies are designed to establish pre-development conditions against which future measurements (monitoring) of these same parameters may be compared. The purpose is to determine changes occurring as a result of OCS development.

If this proposed sale is held, the BLM also will be supporting a proposed monitoring program and special study projects pertinent to OCS leasing in the proposed sale area.

E. Relationship of this Proposed Action to Existing and Prospective Offshore Oil and Gas Development in California

The proposed action would be a continuation of Federal OCS leasing offshore California which began in 1963 and was followed by leasing in 1966 and 1968 in the Santa Barbara Channel area of California. Offshore production in state waters started in 1896, as dis-

cussed in section I.B.2. Federal leasing activity in the Outer Continental Shelf (OCS) has been underway in the Gulf of Mexico since the 1950's.

Currently there are two producing oil fields in the Federal OCS area, Don Cuadras Offshore and Carpinteria Offshore, located in the Santa Barbara Channel (see Figure I-1). Graphic 1, Current Lease Status, found at the end of this statement illustrates the federal lease areas. Part of the Carpinteria Offshore field lies within the California State tideland and submerged land area, with the remainder within Federal lease areas. All of the Don Cuadras field is in the Federal OCS area.

There are five producing platforms in the federal areas with 186 producing wells in operation as of November, 1974 (see Graphic 4, Land Use, for the location of offshore drilling platforms). Output from these wells was 51,000 barrels of oil per day and 20,000 barrels of water per day as of August, 1974. Production in 1973 was 18.78 million barrels of oil and 9.16 million Mcf 1/ of gas (see Section II.G.6., Oil and Gas Resources, for further production details). There has been a total of 197 platform development wells and 79 exploratory wells drilled on Federal OCS Santa Barbara Channel leases to date (September, 1974). Of 61.5 miles of pipeline leading from federal leases in the Channel to onshore, 29.5 miles are in federal water and 32 miles are in state water.

State offshore activity extends from the Santa Barbara Channel south to Orange County within the three mile limit. There are 131

1/ Mcf- Thousand cubic feet

leases covering 165,157 acres on state land and approximately 20 leases covering 20,000 acres on municipal lands developed by nine platforms, seven islands, three piers and 19 shoreside, multiple sites from which 1,606 wells produced 70.58 million barrels of oil in 1973 and 30.6 million Mcf. of gas. Daily production of oil is about 193,000 barrels per day. Again, the reader is referred to Section II.G.6. of this statement for a more detailed breakdown of state production activity.

For comparison, as of October 1, 1974, there have been 26 OCS oil and gas lease sales on submerged federal lands in the Gulf of Mexico, four offshore Pacific coast (three in California, one in Washington/Oregon) and three OCS sulphur and two salt sales in the Gulf of Mexico.

Total acreage leased since the inception of OCS leasing activities through June 13, 1975 is as follows:

<u>Area</u>	<u>Acreage</u>
Louisiana	6,660,098
Texas	2,219,190
LA.-Texas	1,054,356
MAFLA*	617,877
Pacific (Calif., Wash., Oreg.)	1,258,974
TOTAL	11,810,495

Data from June 13, 1975 BLM N.O. OCS Office "Statistical Summary".
 *MAFLA is the acronym for Mississippi, Alabama, Florida, all of which have been relinquished.

As of June 13, 1975, the acreage under current lease was:

<u>Area</u>	<u>Acreage</u>
MAFLA	485,396.89
Louisiana	5,473,880.18
Texas	1,952,572.99
Pacific Coast	346,808.48
TOTAL	8,258,658.54

F. Development of Proposed OCS Planning Schedules for Potential OCS Oil and Gas Leasing and the Department's Proposed Program to Accelerate OCS Oil and Gas Leasing Nationwide.

Proposed OCS Planning Schedules are developed in order to project the timing, size, and location of specific lease sales for an OCS leasing program. General sale areas are identified and, at a later date, tentative acreage figures are set for each proposed sale on the basis of broad resource knowledge. The goal of the proposed schedule is to provide for orderly development of OCS oil and gas resources and to maintain an adequate contribution of OCS production to the national supply.

In developing a proposed OCS planning schedule the Department considers the three leasing objectives that have been set for a Departmental OCS program. These objectives are: 1) orderly and timely resource development; 2) protection of the environment; 3) receipt of fair market value. The overriding factor in planning for OCS leasing is to strive for a supply of oil and natural gas adequate to meet the demand for these resources, consistent with the protection of environmental values. This is the foundation of and justification for the existence of any OCS leasing program. The tentative acreage selection process that follows must consider the need to balance supply with demand. Acreage is tentatively selected in sufficient amount to engender industry interest and promote a fair market return.

The proposed OCS planning schedule is essential as a program planning document to enable the Department to proceed in an orderly

and timely fashion with its process of considering the several proposed and possible lease sales identified in that document. The proposed OCS planning schedule aids Interior in establishing the order in which areas will be examined and in planning the work assignments of personnel and the allocation of resources for the environmental and other studies enumerated. The proposed OCS planning schedule also serves to apprise federal, state, and local agencies, industry, and interested members of the public of the time frame for consideration of potential leasing in the identified areas of the OCS. The proposed OCS planning schedule is a flexible document that is subject to revision at any time. More particularly, the consideration of any proposed or possible sale is subject to being terminated, modified, deferred, or advanced.

In May 1974, the Department announced that it would prepare a draft environmental impact statement on the proposed program to accelerate OCS oil and gas leasing from 3 to 10 million acres in 1975. This proposal considers the entire United States' Outer Continental Shelf. A draft environmental impact statement on this proposed program was published in October 1974, submitted to CEQ and made available to the public for review and comment. Public hearings were held in February on this draft statement in Anchorage, Alaska; Beverly Hills, California; and Trenton, New Jersey.

In November 1974, the Department modified the goal of its proposed accelerated OCS oil and gas leasing program nationwide from

leasing 10 million acres in 1975, to holding 6 proposed lease sales 1/ in 1975 and 6 possible lease sales 2/ per year for the period 1976 through 1978, offering prospects in each frontier area 3/ by the end of 1978. Accelerated leasing remains an integral part of the proposal, but the specific acreage figure has been eliminated.

On November 14, 1974, a new proposed OCS planning schedule^{4/} was announced by the Department of the Interior at a conference with coastal States' Governors. The proposed sale under consideration herein is listed as the 4th sale on that proposed schedule. The 1974 proposed schedule replaced an earlier 5-year schedule that had been issued in July 1973.

The proposed OCS planning schedule, issued in November 1974, was revised in June 1975 to reflect changes in the timetables for considering certain sales listed on that schedule. ^{5/}

1/ A proposed sale, as used herein, refers to a tentative sale as to which tract selections have been made for the purpose of preparing a site-specific environmental impact statement.

2/ A possible sale, as used herein, refers to a tentative sale which has been listed on a proposed planning schedule but has not reached the tract selection stage of the consideration process.

3/ Frontier areas refers to any of the 17 recognized OCS areas in which there has been no prior Federal oil and gas leasing.

4/ See Appendix 3

5/ See Appendix 3

Some of the major resource, environmental, and technological factors weighed in developing the proposed OCS planning schedule issued in November 1974 are as follows:

1. Review of the Council on Environmental Quality's environmental reports concerning the Gulf of Alaska and Atlantic OCS, and consideration of their ranking of areas by environmental risk and their concern for adequate regulation and utilization of technology. The Department has recently responded to this report, outlining the steps being taken on the basis of CEQ's recommendations.

2. Review of the results of Interior's survey of industry, state, and local governments, and interested members of the public concerning resource potential, leasing preferences, and matters of environmental concern. These results were published in June 1974.

3. Collection and examination of considerable amount of resource data gathered in Seismic surveys of these areas.

This proposed OCS planning schedule does not represent a decision to lease in any of these particular areas. It represents only the Department's intent to consider leasing in such areas and to proceed with the leasing development of such areas if it should be determined that leasing and development in such areas would be environmentally, technically, and economically acceptable. Thus, the modification program proposal to accelerate OCS oil and gas leasing entails leasing of some of all frontier areas by the end of 1978.

The Department has revised the content of the draft programmatic environmental impact statement in light of the written comments received on that statement and oral comments submitted at the public hearings

held in February 1975. The final OCS programmatic EIS addresses the proposed program as modified in November 1974 and includes a discussion and analysis of the proposed OCS planning schedule, revised June 1975. The final statement was submitted to CEQ and made available to federal, state, and local agencies, and interested members of the public in July, 1975. The Department has announced that governmental agencies and the public will be able to submit comments on the final OCS programmatic EIS during the 60 day review and comment period following its publication.

As in the case of this proposed OCS oil and gas lease sale No. 35, the Department has committed itself to prepare a site-specific draft environmental impact statement for each OCS oil and gas lease sale that may be proposed. This is in addition to preparation of the programmatic EIS.

No decision will be made regarding the proposal covered by a final OCS programmatic EIS until the 60-day review and commenting period on that statement has expired, and the Secretary's decision will be made only after he has considered environmental, technical, and economic aspects of the proposal. Similarly, if the Secretary adopts an accelerated leasing program that includes a proposed lease sale in the Southern California OCS area, he will make no decision as to that sale until the period for comments on both a final OCS programmatic EIS and a final site-specific EIS have expired, and only after he has considered the environmental, technical, and economic aspects of that lease sale proposal.

G. Deepwater and Subsea Production Systems

Approximately one million acres or 64% of the tracts in this proposed offering are located in waters deeper than 250 meters (820 feet). The present (June 1975) capability of the industry to operate in these areas is described below. There are four prototype subsea production systems either installed in the Gulf of Mexico or under construction. All are in less than 120 meters (400 feet) of water for test purposes but are designed for water depths ranging from 450 to 900 meters (1500 to 3000 feet).

It is likely that if this sale should be held, any deepwater tracts which are leased would not be developed in the next two to three years. During this time, research and development will be continuing with the goal of meeting future development needs. Prior to developing a lease, the operator must submit a development plan to the Geological Survey for approval of design and installation procedures in accordance with OCS Order No. 8. If at that time, it is determined that the technology and procedures proposed for development of a tract present unacceptable environmental risk, (30 CFR 250.12(c) and (d), and 250.34) approval of the development plan would be withheld.

As with all wells, the production from wells completed on the ocean floor must be collected, sent to a production facility, and at some point reach the surface in order that it may be utilized.

To date, the production facilities for subsea wells are generally located on a nearby platform. In this case the production facility itself, separators, etc., would be as described in section 5 of Appendix 8.

There are, however, other production systems in use and several more in the development and testing stages. Since there are so many possibilities regarding subsea production systems it is perhaps best to proceed logically from the well to the final disposition of the production.

1. Well Location

Wells can be drilled vertically from locations conforming to the spacing pattern of the subsea field. In this case flow lines are required from each well to a common point. This common point may be either a surface production facility, an ocean floor production and test manifold, or, possibly, a subsea production facility.

There are two principle drawbacks in developing a field in this manner:

- There is a practical limit to the length of flow line that can be considered. Depending on the production characteristics, wellhead pressure and fluid viscosity in particular, there will be a pressure drop per unit length of line. In some cases this pressure drop could be enough to prevent production from reaching the central collecting point and certainly, as the reservoir pressure declines during the life of the field, problems will develop.

Depending on the type of well completion, the production tree in particular, flow line lengths are critical. If the well is to be maintained by divers and/or surface vessels, the flow line length may not be too important, but where maintenance is to be carried out by pump down, through the flow line (TFL) tools, the length of flow line would be important. Also, if the well is to be remotely controlled, hydraulic lines and/or electric cables may be required to actuate well controls. These would normally parallel the flow line.

Normally, subsea wells are drilled within three miles of the central collecting point and perhaps two miles is a more realistic limit.

- If conventionally moored vessels are used in field development, and later in field maintenance, the presence of a number of lines on the sea floor may hinder the use of anchors and increase the hazard of rupturing the lines.

Wells can be drilled directionally from a common site on the sea floor to bottom in widely-spaced locations to meet the needs of optimum field spacing. Generally, some type of base plate or template is employed to space well heads. These templates may be elaborate and combine functions other than wellhead spacing as described in sections I.G.4.b.,c, and d., or the templates can be simple and merely replace the temporary guide base described in section 3.b.(4). of Appendix 8.

This system is called the cluster concept for subsea completions and the wells can be conveniently connected to a common subsea test and production manifold. In this case only two lines carrying production are required, one to carry the total production from the cluster and the second to carry an individual well's production to a test facility. Depending on the field development plan, additional lines to handle well and manifold control functions may also parallel the flow lines.

2. Well Completion

Down hole completion procedures for subsea wells are as discussed in sections 3.(i) and 4.(e) of Appendix 8. riser pipe and the blowout preventor stack. After tubing is hung and plugged, the BOP stack is removed and the wellhead is set and connected in place.

Wellhead equipment for subsea wells is functionally similar to the equipment described for platform wells and includes all the safety devices ^{previously} described.

The control equipment is necessarily modified in accordance with the type of basic control design - that is diver operated, remote control from the surface, control at atmospheric pressure in encapsulated well heads, etc.

a Diver Manipulated Production Tree

In the simplest form the subsea production tree can be the same as those used on land. The tree is installed by divers and manipulation of well controls would also require divers.

Figure I-2 shows a somewhat more sophisticated tree designed for subsea use. The tree is installed by divers who must also make up the flow line connections. The tree valves are controlled hydraulically from a remote point through hydraulic control lines. Four trees of this type were installed by Phillips Petroleum Company in the El Molino Field in the Santa Barbara Channel in 1963 in 200 feet of water.

The problem with diver operated systems is the diver depth capability. At present working dives are routinely carried out in water depths to 600 feet and they have been carried out in depths of 840 feet. The U.S. Navy has, however conducted working dives on an experimental basis to

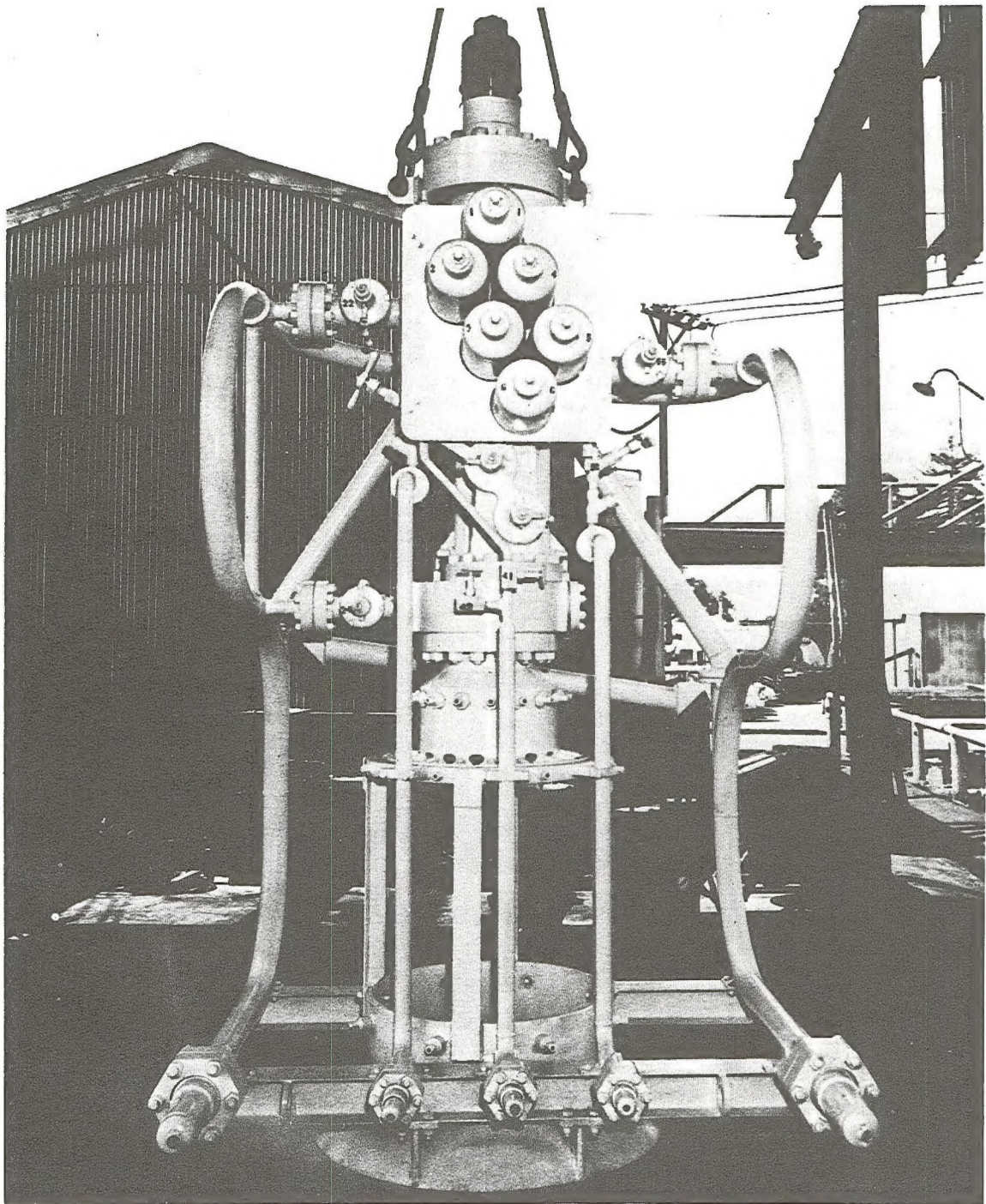


FIGURE I-2 DIVER INSTALLED AND OPERATED SUBSEA TREE

Source: VETCO Offshore, Inc.

depths of 1,010 feet off San Clemente Island, California, and experimental saturation chamber dives have been conducted to a simulated depth of 2,000 feet. The diving industry's depth capabilities have advanced rapidly over the past decade with the advent of saturation diving and through government and industry research and experimentation in the areas of breathing mixtures and diving physiology. Industry experts state working dives are presently feasible to 1,200 feet, at the present state of the art.

Two professional papers, given at the 1972 Offshore Technology Conference, reflect the rapid advancement of deep water diving technology; one by H. G. Delauze and A. Jegau, "A Working Week at 840 Feet in the Open Sea", Paper 1562, and the other by R. W. Long and N. E. Smith, "Hot Water" An Economical Approach to Increased Diver Performance and Safety," Paper 1563.

Mr. R. Parks, Assistant Professor of Marine Technology at Santa Barbara City College, testified, at the public hearing for the Draft Environmental Statement, Santa Ynez Unit in Santa Barbara California, on October 2, 1973, that equipment is available for divers to work at 1,000 feet using saturated diving techniques. He further stated that technology is available for much deeper water and simulated tank tests have actually been made to simulate 2,000 feet of water. It can be anticipated that divers' capabilities will continue to be extended to deeper water.

b. Remote Controlled, Hydraulically Manipulated Tree

Figure I-3 shows a later tree than that discussed in section I.G.2.a. This tree is installed without diver assistance using the same techniques as those used to make up blowout preventer and riser pipe connections during drilling. All valves are controlled hydraulically, or electro-hydraulically where distance attenuates hydraulic response time, from a remote control point. All valves are also of the fail -close type, which means they will automatically shut in the well should loss of hydraulic pressure occur. Flow line connections can also be made from the surface using methods described in section 6, Appendix 8. Four of these trees are installed in 230 feet of water in the Ekofisk field in the North Sea operated by Phillips Petroleum Company.

The particular trees depicted in Figures I-2 and I-3 do not include facilities for through the flow line (TFL) tools, but this is incorporated in the tree shown in figure I-4 .

c. Encapsulated Trees

An encapsulated tree is a conventional tree installed in a chamber that is maintained at atmospheric pressure and includes a means of access from a personnel vehicle. The personnel vehicle can be considered a diving bell with means of connection to the subsea chamber over the wellhead. In this manner, non-diving technical personnel have access to the wellhead controls and can perform all of the functions possible on a land well, including wire-line work.

Several systems have been developed, and they are discussed more fully in section 6.d. One of these, the Lockheed system, was installed by Shell Oil Company in the Gulf of Mexico in September, 1972 in 375 feet of water. In

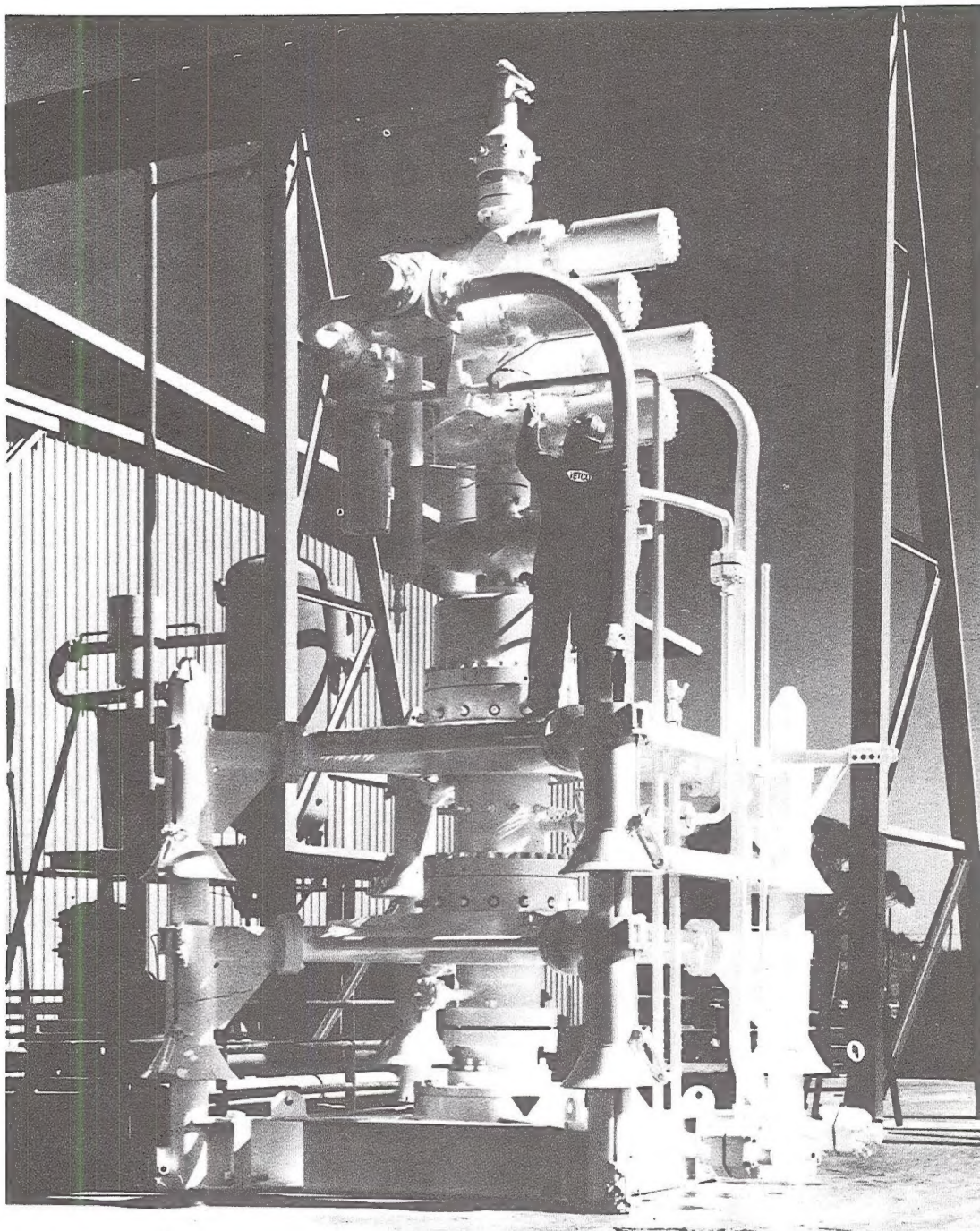


FIGURE I-3. TREE DESIGNED FOR USE IN EKOFISK FIELD (NORTH SEA) BY PHILLIPS PETROLEUM COMPANY. ALL VALVES ARE REMOTELY CONTROLLED. Source: VETCO Offshore, Inc.

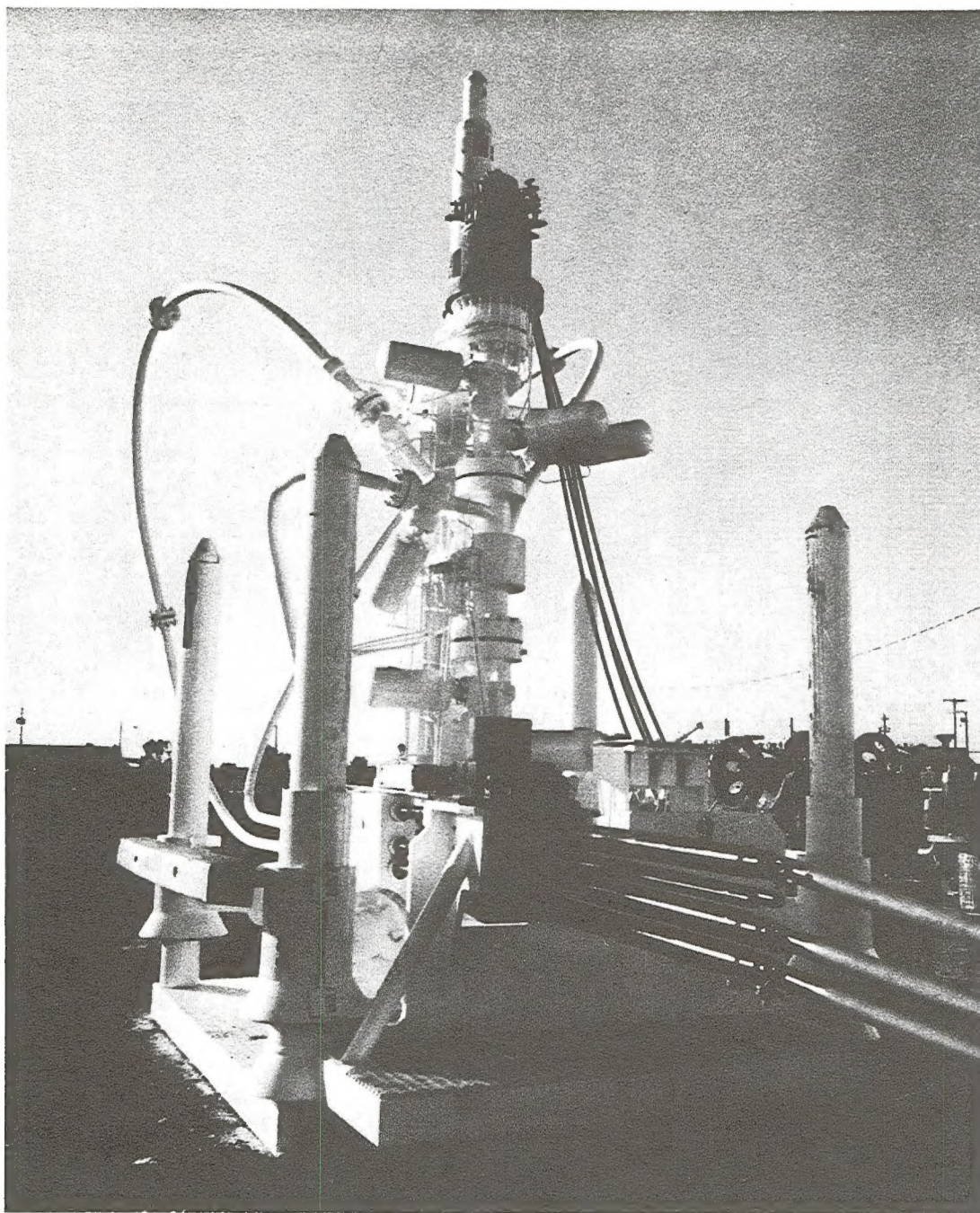


FIGURE I-4. FREE DESIGNED FOR USE BY SHELL OIL COMPANY IN THE GULF OF MEXICO. DESIGNED FOR INSTALLATION WITHOUT DIVER ASSISTANCE AND FOR REMOTE CONTROL OF ALL FUNCTIONS POSSIBLE ON A SURFACE INSTALLATION.

Source: VETCO Offshore, Inc.

1973 the well was successfully re-entered for routine maintenance.

This concept can be expanded to include a complete production system as discussed in section I.G.4. The advantage of course is that well work can be performed at surface conditions (atmospheric pressure) and that the work can be done using conventional oil field tools and techniques with no reliance on sophisticated remote control techniques. These systems are presently viable to at least 1,500 feet and even greater depths can be anticipated in the future. Present limitation is wall thickness (strength) of the enclosure and personnel capsule which in turn is limited by the capacity of the hoisting equipment.

3. Subsea Manifold

A subsea manifold would perform the same function as a manifold on a surface production installation. The purpose of this series of valves is to collect the production from several wells and combine it to a single stream for delivery to a separation facility. There must also be a means of segregating individual well production for metering and testing. This is accomplished by the series of valves included in the manifold.

The manifold, which can be operated hydraulically or electro-hydraulically from a remote control point can be "wet" or it can be encapsulated. These systems are described in section I.G.4. The value of such a system is to permit a cluster of subsea wells and avoid the number of flow lines required if wells were widely spaced.

4. Subsea Production Facilities

The ideal for an offshore oil field would be to have all production facilities located on the sea floor. This is within the realm of possibility and several systems have been designed and are being tested.

a. Zakum Field

A subsea production system was installed in the Zakum field of Abu Dhabi Marine Areas Ltd. in the Arabian Gulf in 1970. The field is operated by British Petroleum and Cie. Francaise du Petroles. The system is electrically operated and diver maintained; the site is in 70 feet of water and was selected so as to be readily available for diver maintenance. The system includes all well controls, a gas-oil separator, and a gas driven generator for electrical power. The system is purely experimental, but it indicates what may be possible in the future.

b. Exxon Submerged Production System (SPS)

This system has been proposed as a possibility for the development of the Santa Ynez Unit in the Santa Barbara Channel and was discussed in the Geological Survey's environmental impact statement covering this subject.

Exxon's submerged production system (SPS) has successfully completed land tests. The SPS is a cluster of subsea wells and associated production controlling, separating and pumping equipment mounted on a subsea template structure. The produced fluids are transported to surface processing facilities via pipelines to shore, to a platform or to a production riser which connects to a floating vessel. The subsea equipment is remotely controlled and monitored from the surface facilities by an electro-hydraulic supervisory control system. Pump-down tools are used to service wellbore equipment and a manipulator operated from the surface is used to replace non-operative subsea equipment. All elements of the system have been designed and land tested. Work is in progress to perform an offshore test of the complete system.

The system essentially consists of a cluster of wells drilled through a seafloor template and connected through a manifold system. The manifold system is surrounded by a track on which a wellhead and manifold manipulator runs. The manipulator is controlled from the surface and can control all well control functions. Provision is also made for access to the annulus of each well. The manipulator maintenance system is shown in figure I-5.

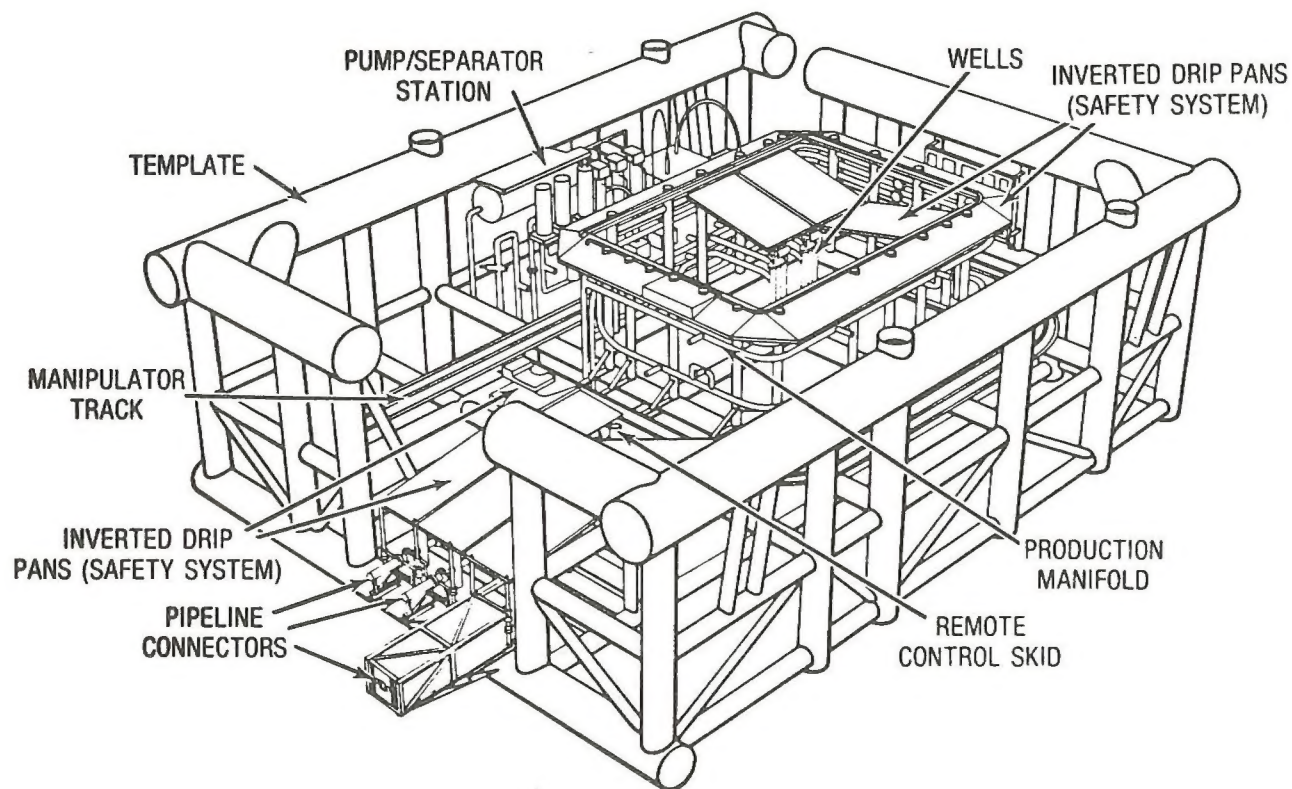


FIGURE I-5. EXXON SPS Manipulator System
Source: Exxon Company, U.S.A., 1971,
Supplemental Plan of Operations,
Santa Ynez Unit.

The submerged production system (SPS) provides both equipment and procedures which span the production requirements of a field from the time development drilling starts to field abandonment and from wellbore equipment at the completion interval to the processing equipment at the common carrier custody transfer point. The SPS is composed of eight functional subsystems as follows: 1) the drilling and completion subsystem, 2) the manifold subsystem, 3) the remote control subsystem, 4) the pump/separator subsystem, 5) the template subsystem, 6) the pipeline connection subsystem, 7) the production riser and floating facility subsystem and 8) the maintenance manipulator.

The final series of land tests on a prototype, 3-well, subsea production manifold and a maintenance manipulator were performed in a water-filled pit where the underwater production equipment was automatically operated to control well streams simulating liquid, gas-liquid, and sand laden production. In this testing, the prototype equipment met or exceeded design specifications. In addition, the maintenance manipulator was deployed from a surface vessel to a mock-up installation in 425 feet of water to demonstrate its ability to land on its track which surrounds the underwater equipment. This development test, when coupled with the pit test, proved the manipulator to be capable of performing the maintenance tasks. Results of tests on the SPS wellbore equipment and on a pre-prototype pump/separator subsystem have indicated the utility of these equipment subsystems in performing their functions. Tests simulating operating conditions have permitted the design of prototype pipeline connecting equipment needed for the SPS.

An offshore test of the Exxon SPS has commenced in the Gulf of Mexico off Louisiana. In this offshore test, installation, production and maintenance operations in the Gulf of Mexico will be performed in a manner representative of producing a deepwater field with an SPS and the full-scale depth-capable equipment will be used. The purpose of the test is to evaluate the cost and performance of the equipment and technique during installation, operation and maintenance activities. The results of extensive land testing indicate that the equipment will function properly and this offshore test will provide data necessary to evaluate both equipment and procedures.

The test includes a template with producing equipment placed on the sea floor in 170 feet of water in West Delta 73 Field which is 27 miles southeast from Grand Isle, Louisiana. Three wells in the test will deliver production to a manifold which surrounds the well bay, then to a subsea separator and fluid pumps. At that point, gas will flow via pipeline to the nearby "F" platform. Liquid will be pumped using submersible electrical pumps via an articulated production riser to producing facilities on the platform. The riser will be tested to confirm its capability although no oil will be loaded to a service ship in the pilot test. The test plan for the template calls for all work on the sea floor to be done remotely without the use of divers, simulating deep water application.

The template was fabricated and equipment installed and tested in McDermott's yard in Morgan City, Louisiana, over a period of 15 months beginning in

May, 1973. The template was launched much like a conventional platform jacket on October 19, 1974. Subsequently, the unit was keelhaunched under a drill ship, the Glomar "GRAND BANKS", then lowered to the sea floor with the rig draw works. Four pilings have been drilled in and cemented to the sea floor and the template leveled. Pump caissons have been installed.

Five pipelines have been laid and connected to the template by remotely controlled operations. Two of these lines (1 - 3" ID pump down tool line and the 8" gas line) connect directly to the "F" platform. The other three lines (a 3" ID pump down tool line, 3" ID gas injection line and 8" oil line), also terminate at the "F" platform by way of the production riser. The two cables, a 35 kv cable supplying power to the fluid pumps and a 5 kv remote control cable, have been laid. As of June 1975, two wells, one tubingless and one open hole gravel pack, have been drilled.

Another open hole gravel pack has yet to be drilled. Also, the maintenance manipulator must be deployed to make planned connections on the sea floor equipment. Pipeline pumps have not yet been installed. Although there have been problems as would be expected in a test of this magnitude, no basic flaws have been detected in the SPS to date. Expected completion date and initiation of production is early fall 1975.

The test will have a minimum duration of three years beginning in 1974, but production and maintenance operations will probably be continued until their continuance can no longer be justified.

c. Lockheed Subsea Completion and Production System

Shell Oil Company and Lockheed Petroleum Services joined efforts to develop and field test an ocean-floor system for completing and producing wells. The system is based on the concept of housing more-or-less standard equipment in one-atmosphere chambers. The chambers can then be linked together with subsea pipelines to form a complete producing system. Servicing the equipment inside the chambers can be performed by experienced oilfield workers, transported to and from the chambers in a dry, one-atmosphere diving capsule.

The current joint program consists of three phases. Phase I, the Lockheed Petroleum Services (LPS) one atmosphere system was completed and installed in 1972, for Shell Oil Company in the Gulf of Mexico (Main Pass Block 290) at a 375 foot water depth. There have been no major technical problems with the well-head chamber and the well has produced over $\frac{1}{2}$ million bbls. of oil.

Phase II, the subsea manifold center, is scheduled to be installed in Eugene Island Block 331 Field in the summer of 1975. The LPS wellhead cellar is supported on the casing head housing and is surrounded by the guide frame whose base is 2 - 5 feet above the sea floor. This is all supported by a 29- $\frac{1}{2}$ " diameter drive pipe penetrating the sea floor. Foundation for the manifold center is a barge that carries the system to the site and is sunk to form the base on the sea floor.

All LPS equipment and materials have been carefully selected for the appropriate pressure rating and subjected to extensive testing. Every well is equipped with automatic fail-close valves and remote shut-in controls actuated hydraulically from the platform. A control panel on the platform regulates all the sensing and remote functions and include:

- 1) Remote actuation and position control of all remotely operated valves and chokes.
- 2) Pressure sensors in pipelines.
- 3) Sequential shut-in system.
- 4) Testing of the emergency shut down system (ESD).

An ESD condition will sequentially close the manifold center's hull valves and subsea Christmas-tree's fail-safe valves (all master and wing valves simultaneously). The tubing removable surface controlled sub-surface safety valves (SCSSV) at Eugene Island is a ball type which was updated from the storm choke used in Main Pass to meet OCS Order No. 5.

All oil and gas pipelines will be equipped with automatic shut-in valves connected to ESD and remote shut-in systems. Hydraulic lines are equipped with back-up systems if the ESD fails.

The third phase will consist of a subsea pumping station, but it will not be installed until results of phase II have been analyzed. It is anticipated that data from these tests will provide the sound basis necessary to project design and cost criteria for application in up to 3,000 feet of water.

In September 1973, Shell, utilizing the atmospheric diving system of Lockheed Petroleum Services, Ltd., successfully re-entered and performed maintenance in a subsea wellhead chamber of atmospheric pressure in 375 feet of water in the Gulf of Mexico, Offshore Louisiana. The primary purposes for the re-entry were to locate and repair a leak in the hydraulic control system, observe the condition of chamber and tree components after one year of operation, and provide diving experience for Shell personnel.

The chamber and internal components were found to be in excellent condition during the first dive. Nine dives were made and all work was completed as planned under ideal weather conditions during the seven day period.

In the first year the well produced 263,000 barrels of oil and 83 million cubic feet of gas and was producing at a rate of 1,350 barrels per day and 450 thousand cubic feet per day from two oil zones. Maintenance and remedial experience has included three TFL (through-the-flowline) operations, where tools are pumped through the tubing, to service subsurface controls and acidize the lower zone, and the reentry into the WHC (wellhead Chamber) described above.

Two examples of the Lockheed system for wellhead equipment are shown in figure I-6. The chambers shown are those permanently installed on the wellhead and the upper hatch indicates where the service capsule is attached. After the capsule is connected, the chamber below the capsule and above the entry hatch to the work chamber, is pumped dry and the atmosphere is tested prior to opening the hatches.

d. SEAL Subsea Completion and Production System

Subsea Equipment Associates Limited (SEAL) has been principally funded by British Petroleum, Mobil Oil Company, Compagnie Francaise des Petroles, Westinghouse Electric Corporation, and Groupd Deep, the latter a consortium of European Contractors. Associate members of the group include Conoco, Sunoco, Phillips, ELF/ERAP, and Petrobras.

SEAL currently has under development three subsea oil and gas production systems. Two of the systems undergoing tests are designed for use in foreign fields where high production rates are prevalent. SEAL is also testing a subsea oil production system in the Gulf of Mexico which is designed primarily for utilization with large

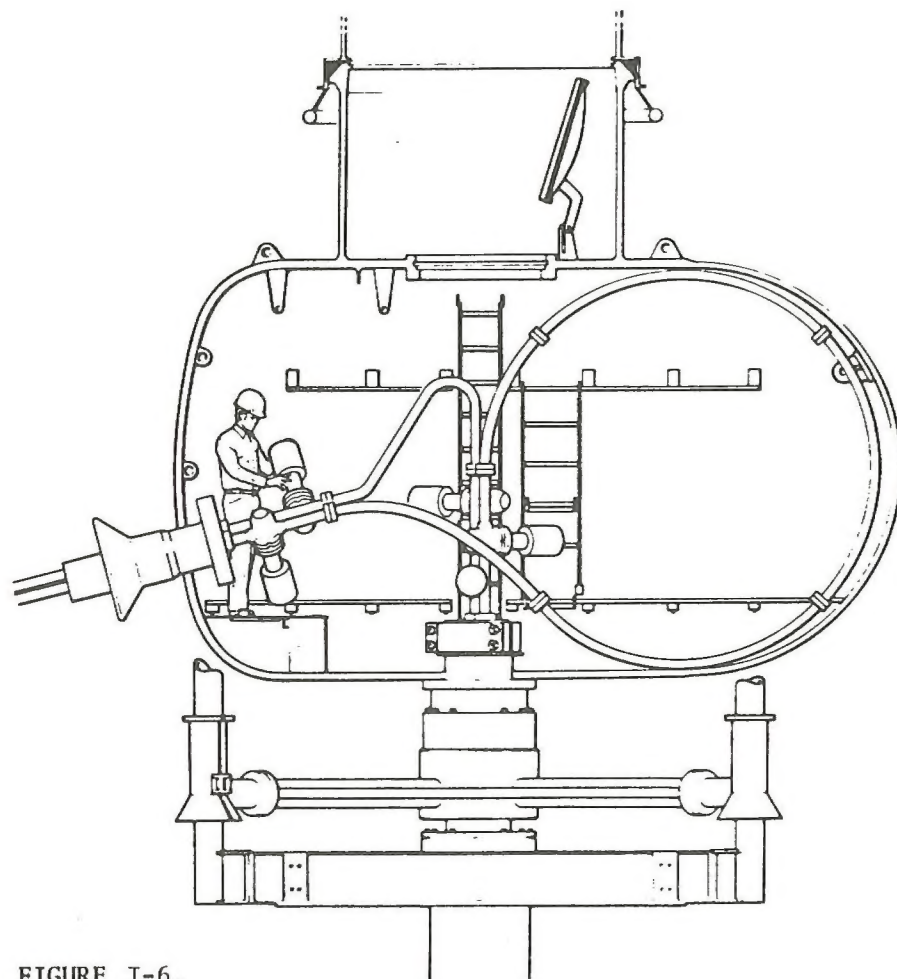
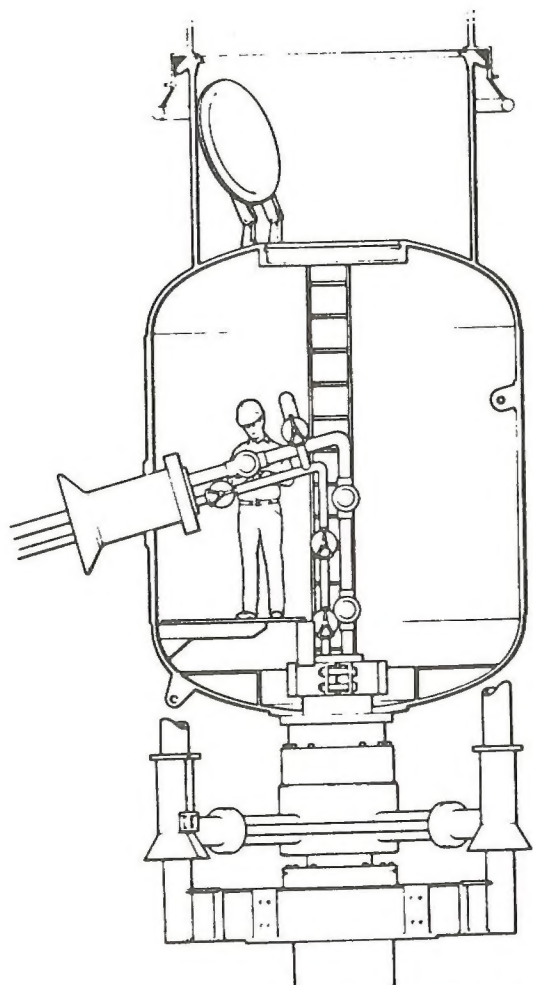


FIGURE I-6.

LOCKHEED ONE-ATMOSPHERE SUBSEA COMPLETION SYSTEM

- a. For wellhead installation where TFL tools are not required.
- b. A wellhead cellar designed to enclose the TFL tubing loop.

Source: Lockheed Petroleum Services, Ltd. (Also presented at the Sixth Annual Offshore Technology Conference, Houston, Texas, May 6-8, 1974.)

numbers of domestic low-production wells of less than 1,000 barrels per day which in turn generally require significant maintenance. Sun Oil Company is participating in the test project in the Gulf.

Essentially, the SEAL system is similar to the Shell-Lockheed system where working areas are enclosed in atmospheric chambers and access is available through personnel transfer capsules lowered from a surface vessel. Systems have been designed for individual well completions, cluster type well completions, a production manifold station, a subsea separation facility and a subsea pumping station.

As in other similar systems a base plate is hydraulically connected to the wellhead. For a multiple well system the base plate serves as a drilling template for directionally drilled wells and part of the structural piping is used in the manifolding system for the wells. The subsea work enclosure is then connected to the base structure and has provisions for personnel entry through a hatch from a personnel transfer chamber. The configuration of the work chamber can be varied depending on the water depth, number of wells associated, production rates, etc. The chamber provides a dry working environment on the ocean floor at atmospheric pressure.

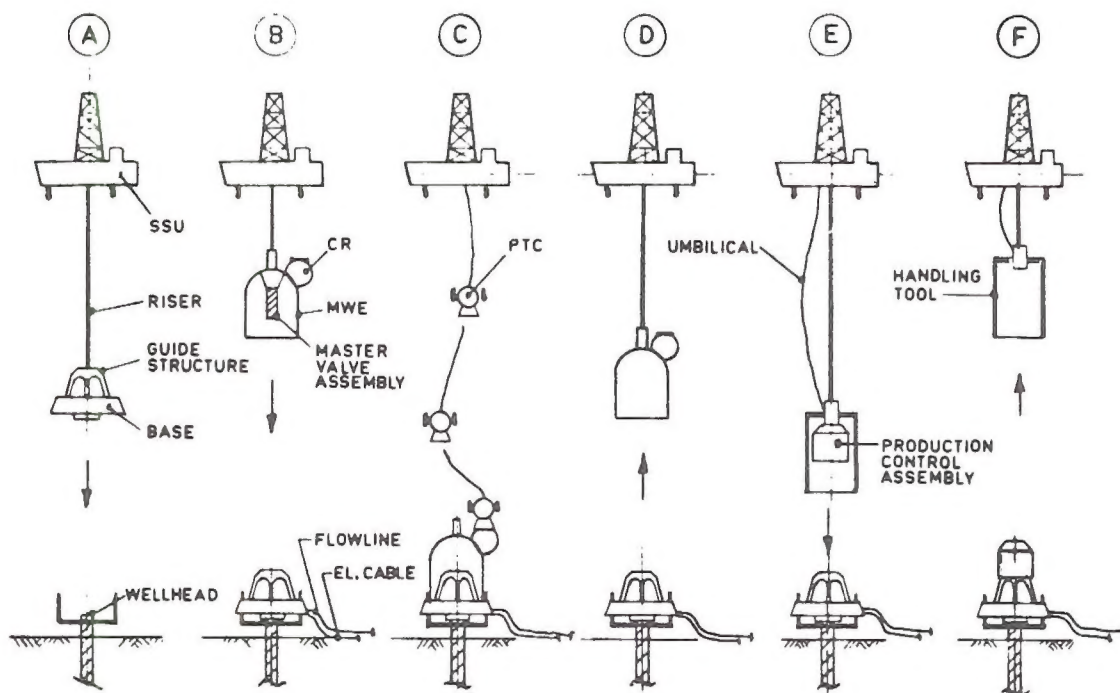
Phillips Petroleum Company is presently completing exploratory wells in the Ekofisk field in the North Sea in about 220 feet of water using this method. They are completing the well and connecting the base plate and lower master valve before releasing the drilling rig. The upper portion of the wellhead assembly (the work chamber and associated valves and piping) will be installed when production facilities are available. This installation can be made with a small support vessel without requiring the services of an expensive

drilling vessel. Previously, exploratory wells were either abandoned, or temporarily abandoned. Abandonment represents a loss of considerable investment and if temporarily abandoned, a drilling vessel would be required to re-enter and complete the well.

In October of 1973, a series of tests involving the SEAL well completion system were started in the Gulf of Gabes, Tunisia. The first tests were in approximately 200 feet of water and the next step will be to test the system in about 575 feet of water in the same area. The system is designed to be used in waters over 1,500 feet in depth.

The vessel used in the Gulf of Gabes test was dynamically positioned using the "taut wire" system. The base plate was lowered on pipe and hydraulically connected to the well head, the master valve assembly was then lowered inside a manned work enclosure (MWE) and manually connected by personnel within the MWE. The MWE was retrieved and remotely controlled production assembly (tree) was hydraulically connected to the master valve assembly. Since the MWE was lowered on drill pipe, wire line operations and well circulation could be conducted from the surface vessel. Figure I-7 shows the sequence of operations followed in these tests. These tests are described in a paper, "Handling the SEAL Intermediate System for Subsea Wellhead Completions from the Support Vessel 'Tarabel'", by Mercier, Higler, Vine, and Darnborough of Subsea Equipment Associates, Ltd. The paper was presented at the 1974 Offshore Technical Conference in Houston, Texas. The paper is numbered OTC 1941.

Another test of the SEAL system is underway in the Gulf of Mexico. This involves a multi-well system and it is described in a paper titled "Subsea



- A - Lower the seal base from the surface support unit (SSU) with internal guide structure attached to it onto wellhead.
- B - Lower the master valve assembly inside the manned work enclosure (MWE). Attach flowline and electric cable to base.
- C - Personnel transfer to MWE to attach master valve assembly to wellhead and connect flowline and electric cable to master valve assembly. (Atmospheric conditions inside MWE)
- D - Raise the MWE leaving behind the master valve assembly.
- E - Lower the production control assembly inside its handling tool and latch it to the master valve assembly.
- F - Operate the master valves with the handling tool. Operate the production control assembly from the support vessel (SSU). Raise the handling tool.

FIGURE I-7.

INSTALLATION SEQUENCE OF SEAL INTERMEDIATE SUBSEA WELLHEAD COMPLETION SYSTEM

Source: Subsea Equipment Associates, Ltd. (Also presented at the Sixth Annual Offshore Technology Conference, Houston, Texas, May 6-8, 1974)

Manifold System" by Chatas and Richardson, Seal Petroleum Company. It is numbered OTC 1967 and was presented at the 1974 Offshore Technical Conference in Houston, Texas.

Testing started by simulating field production on dry land in 1971, in Long Beach, California, where the prototype was constructed. In 1972, the unit was transported to the Gulf of Mexico and installed in 247 feet of water 800 feet from a Sun Oil Company production platform at Main Pass 293A. First tests were conducted by diverting production from wells on the platform through the manifold system. After processing, the production was returned to the platform; additional drilling operations were started in December, 1973, and the test was completed in September 1974.

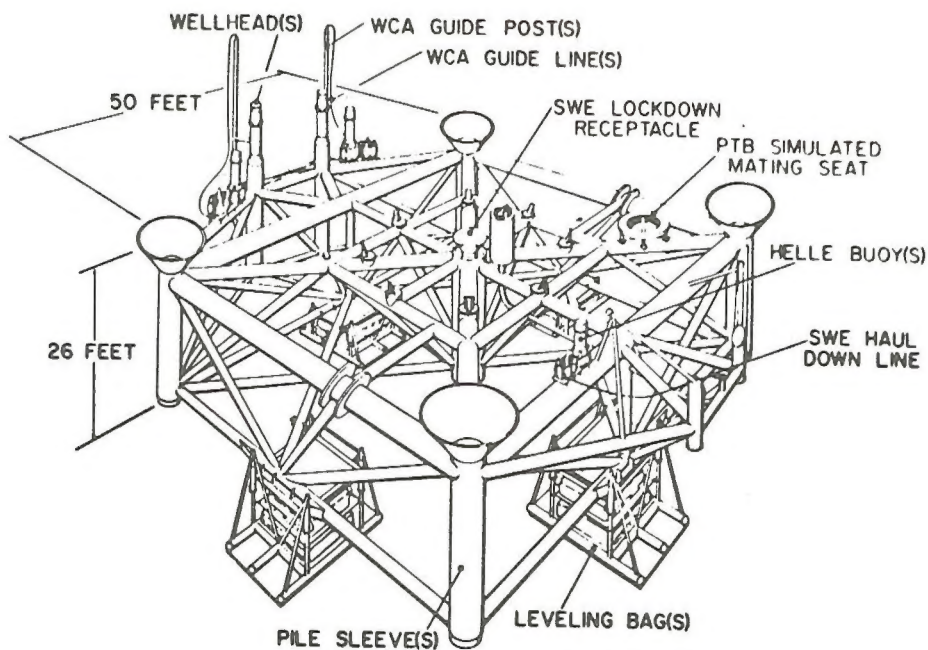
During the commissioning and check-out phase of the test, 56 entries by personnel were made into the subsea work enclosure (SWE). Most of these personnel were not divers, but regular oil company personnel. Over 90 automatic operations of pump-down tools were performed, principally to remove paraffin deposits in the wells. These tools were pumped through the flow line network, to the platform, down the well and returned. The personnel transfer bell used in these tests is capable of transporting five men into the subsea structure.

The base of the SEAL Atmospheric System (SAS) and the subsea work enclosure (SWE) used in the Gulf of Mexico test are shown on figure I-8.

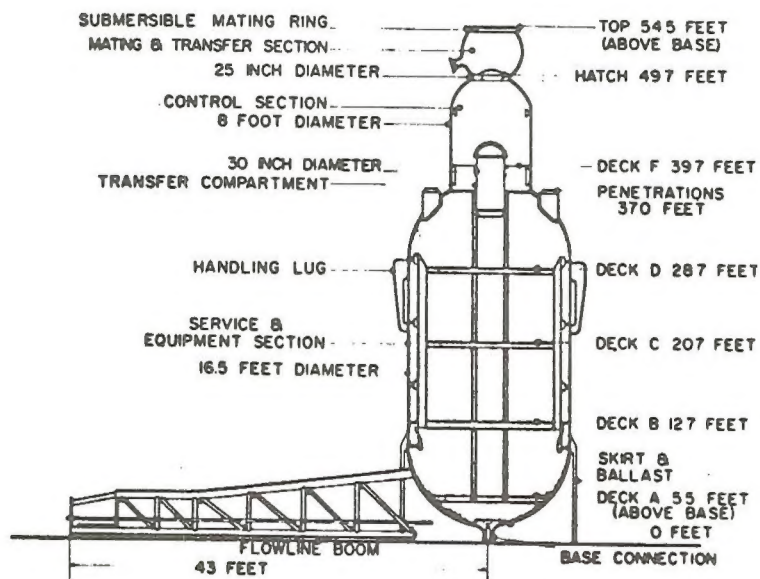
The SEAL Atmospheric System (SAS), which is being tested in the Gulf of Mexico, is based on the use of a large habitat type structure permanently installed on the sea floor to house oil field equipment. The SAS system incorporates a subsea manifold system in which various oil field production equipment can be installed depending on the application.

The three major elements being investigated in conjunction with the SAS Test Program are as follows: 1) the Subsea Work Enclosure (SWE), 2) the automatic production control system, and 3) automatic well maintenance system based on use of TFL (through-the-flowline) tests.

A test separator located within the SWE was a vertical two-phase separator capable of handling produced volumes of approximately 402 B/day oil and 760,900 mcf of gas per day, and due to the characteristics of wells produced through the SWE during the tests, the separator was operated at full capacity and demonstrated repeatability of each well tested and correlated accurately with production data available on each well.



a. Base & wellhead connector assembly



b. Subsea work enclosure

FIGURE I-8. SEAL SUBSEA MANIFOLD SYSTEM

Source: Subsea Equipment Associates, Ltd. (Also presented at the Sixth Annual Offshore Technology Conference, Houston, Texas, May 6-8, 1974)

The separator instrumentation was of a conventional nature utilizing temperature, pressure, and differential pressure on gas meter run and a net oil computer and displacement meter to give quantity and percentages of oil and water.

A common approach in the SEAL systems has been the use of trained oil field personnel on the sea floor. The maintenance personnel are transported from the surface to the subsea structure in a Personnel Transfer Bell. Test operations have proven conclusively that the vehicles are efficient and can be operated safely.

Future applications of this concept would be as a manifold center, a test separator center or a complete oil production system. In a similar manner to the other systems, men are transported to and from the Subsea Work Enclosure (SWE) through the use of a Personnel Transfer Bell. The men perform their duties at atmospheric pressure.

e. Other Submerged Production Systems

Other submerged production systems are in the design or test stage. Deep Oil Technology, Inc., Transworld Drilling Company (a subsidiary of Kerr-McGee Corporation), and Standard Oil of California all have systems that have not yet been fully developed. The Transworld system is similar to the Lockheed and SEAL systems

where an underwater work chamber at atmospheric pressure is utilized. The main difference is that wellheads would be maintained in a wet atmosphere except when work was actually in progress with the underwater work chamber in place. Construction is in progress on prototype models and the system is designed to be operable in water depths to at least 1,500 feet.

f. Floating Production System

A possible production system where production from subsea wells is directed to a surface vessel containing separation equipment is more likely to be used in deep water where platform costs become prohibitive. A moored vessel could be connected to an underwater well manifold by a production riser. The vessel could be simply a separation facility and direct oil to a floating storage facility or the two functions could be combined. The vessel could be either a conventional ship type or a version of a semisubmersible hulls used in exploratory drilling. An adaptation of the semisubmersible type hull was tested off the coast of Scotland for a period of nearly two years from 1963 to 1965. This vessel was moored using the tension leg technique whereby anchor points were established by drilling in and cementing piles in the sea floor. The vessel was then connected to the anchor points by wire cables and by alternately taking in on the cables and flooding the buoyancy chambers, the vessel reached its predetermined buoyancy point with the buoyancy chamber

about 80 feet below the surface. The water was then expelled from the buoyancy chamber leaving the wire cable "legs" in tension. Even in severe weather, the movement of the vessel was negligible since the only resistance offered to the sea was by the legs connecting the work platform to the buoyancy chamber which is itself below the depth affected by wave action. This test is described in OTC paper 2104, "The Design and Field Testing of the "Triton" Tension-Leg Fixed Platform and its Future Application For Petroleum Production and Processing in Deep Water," by R. David McDonald. This paper was presented at the 1974 Offshore Technical Conference in Houston, Texas. A similar test is now (June 1975) underway off Santa Catalina Island in Southern California.

g. Summary

The Shell-Lockheed, the SEAL and the Exxon SPS Systems are undergoing operational tests in the Gulf of Mexico at this time. The three systems have the capability for remote safety inspections as well as visual inspection in the underwater chambers. All submerged production systems must be approved for installation by the Geological Survey and must conform to regulations. As of June 1975 no applications for a fully operated installation of any such system have been received by the Geological Survey.

Servicing and maintenance for the Shell-Lockheed and SEAL Systems will be performed in a similar manner as experienced oil field workers will be transported to the encapsulated wellhead chamber at the sea bottom. Diving capability may be required for special type maintenance outside the chambers.

Maintenance and service can be performed on the EXXON System mechanically by remotely activating a manipulator, but diver capability may still be required.

It is likely that for the near future most subsea completions will be for single well completions and possibly some cluster type completions with a subsea manifold where locations cannot be reached by drilling from a platform. Production from such completions will be directed to surface separation facilities on a platform. Perhaps in a few years a complete subsea production facility will be feasible, but it is not likely that their use will be widespread very soon.

Should a blowout result from a remedial workover operation on a multi-well template at a 2000 foot water depth location, there are major differences when compared with a conventional producing platform. First, there is no possibility of fire or explosion to damage a support structure or other wells. This could possibly permit kill

operations through the well bore. In any case a relief well could be drilled. Second, aside from fire or explosion, damage during a blowout from the erosional effects of escaping fluids or formation particles at high velocities can lead to extensive well head damage and greater flow from the well. At a 2000 foot water depth location, the fluids at the well head are restricted by ambient on bottom pressure of about 900 psi. This back pressure on the well will greatly reduce its flow capability and negate the velocity effects of gas expanding to atmospheric pressure. It should be noted that in the case of a blowout of a completed well during remedial workover operations not requiring a drilling rig, some mobilization time, which would be up to a month or more, could be required to secure a rig to drill a relief well. The time element would normally depend on travel time to the location and on availability of a suitably equipped rig. Rigs are normally made available cooperatively as an industry practice in the event of such an occurrence.

Oil spill containment and clean up for a blowout in 2000 feet of water would require booms and skimming equipment down current from the blowout location at a point where the oil surfaces. Escaping gas in this water depth would not be an environmental hazard. The relief well drilling rig would of course, be located up-current from the blowout location and would not interfere with clean-up operations.

Significant problems have been encountered and resolved during the evolution of subsea production systems and, prior to installation in water depths greater than 700 feet, further testing is required to improve and demonstrate the reliability of such systems. As early as 1962, subsea production systems were installed in more than 250 feet of water; however, investigation revealed that some early deep-water installations were made prematurely when certain components were little beyond prototype state. The recent trend has been to install such subsea system components in shallow water for field testing until dependability can be ensured for use at greater depths. An example of this trend is the Exxon Submerged Production System installed in the Gulf of Mexico in 170 feet of water for field testing prior to being considered for installation at greater depths such as in the Santa Barbara Channel, Santa Ynez Unit.

Prior to acting on a specific request to install a subsea production system, the Geological Survey would take into consideration the results of all testing, including offshore subsea field operations as well as diver depth capabilities. Since such systems are still largely experimental, a specific proposal would be carefully studied before granting approval and the need for supplements to this Statement would be determined by environmental assessment at that time.

II. Description of the Environment

This section presents a description of the environment in the region in which the proposed lease sale is intended to be held. The series of 15 graphics (attached) illustrates the location of the tracts proposed for leasing in relationship to the various facets of the physical and cultural environment of the Southern California Borderland. This section will emphasize those facets of the environment which could be impacted upon by activities resulting from this proposal and those which could significantly affect the activities resulting from the proposal. References cited for all parts of Section II. are listed in Appendix 10.

A. Geological Framework

The proposed leasing tracts lie on the continental shelf, often called the Southern California Borderland. The area extends more than 100 miles offshore. Unlike most continental shelves, which are smooth slopes, the California Borderland consists of seven major islands, nine basins and several ridges and banks. The true continental slope begins at the Patton Escarpment.

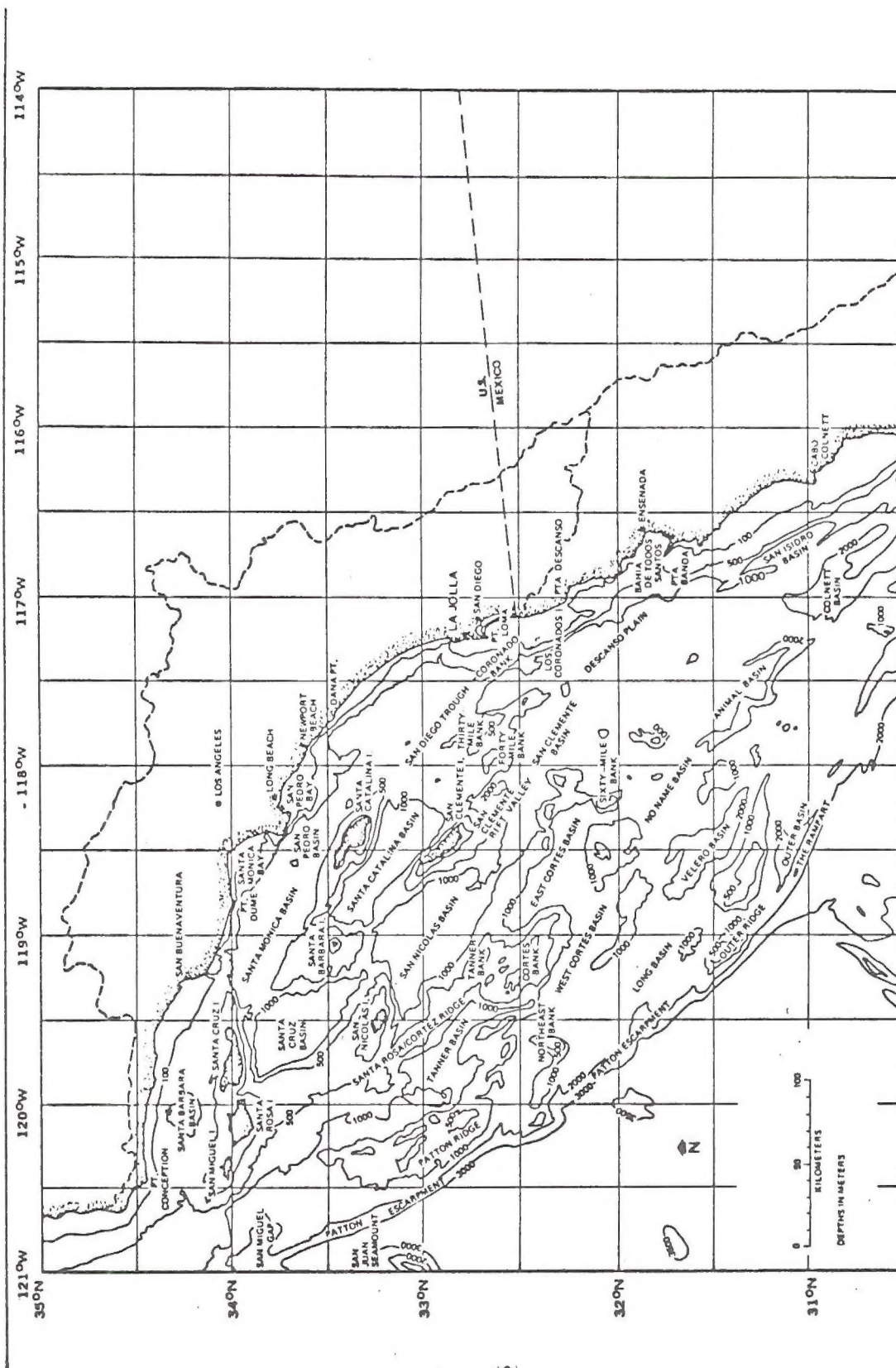
The Borderland lies within two of California's geomorphic provinces, the Peninsular-Range Province and the Transverse Range Province (Fig. II-1 and Fig. II-2). The proposed lease area lies within the Peninsular Range Province and is bounded by the Southern California Mainland Coast on the east, the Mexican border on the south, the Patton Escarpment on the west, and the Channel Islands to the north.

1. Peninsular Range Province

The Peninsular Range of California trending NW-SE extends from south of the Santa Monica Mountains, the northern limit of the Los



Fig. II-1 Physiographic provinces of California
(source - Cal. Div. of Mines & Geology)



Angeles Basin, to south of the Mexican border. The ranges are separated by longitudinal valleys which trend NW-SE. Many of the valleys represent active branches of the San Andreas Fault System. The topography is similar to the coast range with elevations of 900-1200 m (3000-4000 ft.) common. The southern Channel Islands (San Nicholas, San Clemente, Santa Catalina, and Santa Barbara) are included in the Peninsular Range Province.

2. Transverse Range Province

This province is oriented in an E-W direction and is a series of mountain ranges and valleys generally made up of late Mesozoic and Cenozoic age sedimentary rocks. The components of the Transverse Range include both the lowlands of the San Bernardino and Los Angeles plains of the east (these rise abruptly northward) as well as the San Bernardino and San Gabriel Mountains. The latter are two of the most rugged and highest ranges in Southern California. Westward, the San Gabriel Mountains split into two mountain chains, including the Santa Ynez Range (north) and Santa Susana Range (south), separated by the Santa Clara Valley. Westward from Los Angeles stretch the Santa Monica Mountains. The four northern Channel Islands (San Miguel, Santa Rosa, Santa Cruz, and Anacapa) are projections of the Santa Monica Mountains. North of the islands and included in the Transverse Range Province is the Santa Barbara Channel.

The topographic high point of the Channel Islands is 661 m (2167 ft) on Santa Cruz Island. Numerous closed submarine-basins offshore, separated by submarine ridges, are the dominant bathymetric features (Fig. II-2 and Fig. II-3).

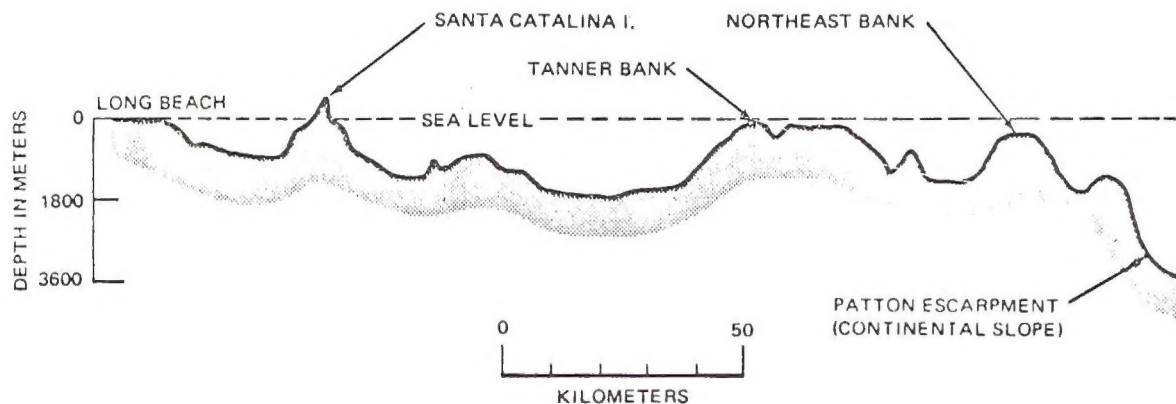


Fig. II-3 A Typical Profile of the Sea Floor Off Southern California. From Shepard 1963, fig. 130.

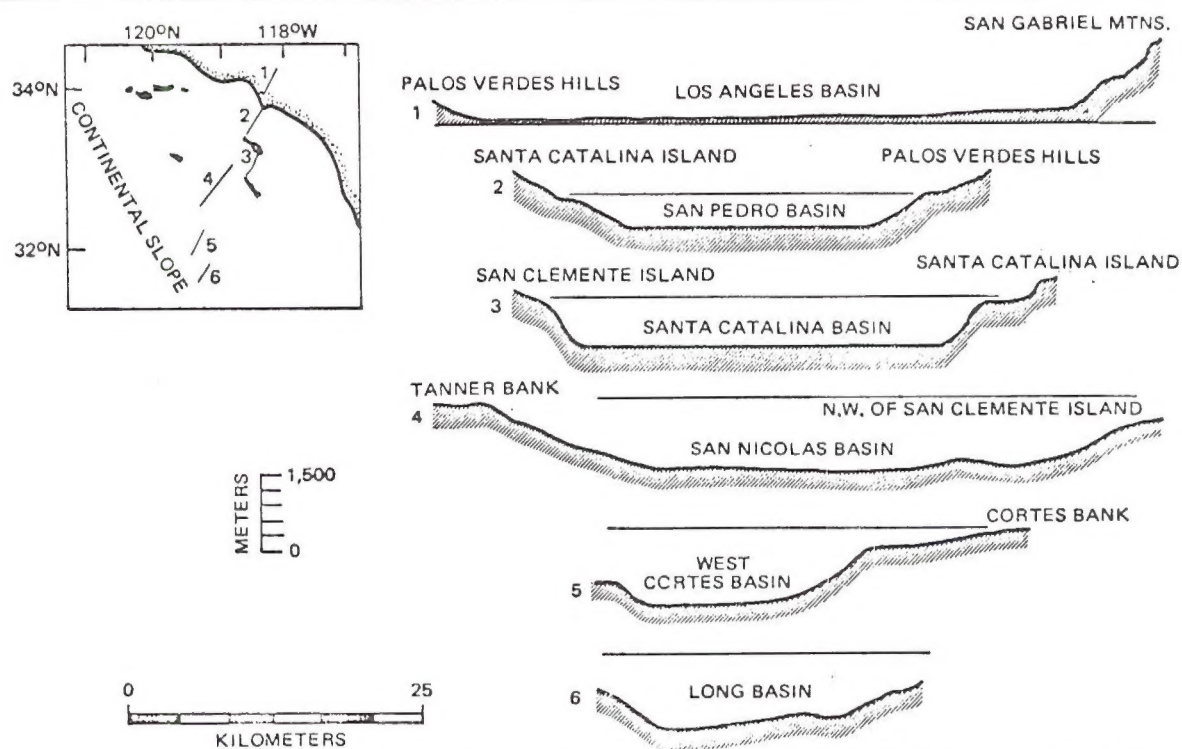


Fig. II-4

Cross Sections Showing the Inverse Relationship of Shoaling, Broadening, and Flattening of Basins with Distance from the Mainland Shore. From Emery 1960, Fig. 50.

The depths in the offshore vary greatly. Submarine ridge crests reach within 4 m of the surface while the larger basins have depths as follows:

1) Catalina Basin	1350 m (4428 ft)
2) East Cortez Basin	1950 " (6396 ")
3) San Clemente Basin	2107 " (6911 ")
4) San Nicholas Basin	1826 " (5989 ")
5) San Pedro Basin	900 " (2952 ")
6) Santa Barbara Basin	625 " (2050 ")
7) Santa Cruz Basin	1966 " (6448 ")
8) Santa Monica Basin	948 " (3109 ")
9) Tanner Basin	1549 " (5081 ")

Many of the offshore basins have been filled with great thicknesses of late Cenozoic marine sediments and likely are similar to onshore Los Angeles and Ventura basins. Nearshore basins are generally shallower and broader and have more regular floors than basins further offshore. Also, they receive the majority of the terrestrial sediment load. The larger dimensions of the basins roughly parallel associated land features. Thus, the Santa Barbara and filled Ventura Basin have an east-west trend parallel to the Transverse Ranges. The other submarine basins have a northwest-southeast trend parallel to the Peninsular Ranges of Southern California. The true continental slope begins at the Patton Escarpment--100 miles offshore. Water depths exceed 4000 m (13,120 ft.).

Very little detailed geological data has been gathered in the offshore region, other than geophysical and shallow core data. Much of the knowledge of the Borderland came from an examination of outcrops in the Channel Islands and from inferences based on mainland interpretations.

Stratigraphy and general geology are covered in detail in Appendix 10, A.1. Very briefly, however, on the mainland coast and on the islands, basement rocks consist of several distinct types. All are believed to be

pre-late Cretaceous in age. Unconformably overlying the basement rocks are thick sequences of Upper Cretaceous age sedimentary rocks. Lower Tertiary marine strata, primarily Eocene in age, are widely distributed in the Santa Ynez Mountains, where they consist chiefly of deep-water sediments that may be as much as 6100 m (21,000 feet) thick. Strata of Oligocene age are predominantly nonmarine. Throughout coastal Southern California and the Borderland, sedimentary and igneous rocks of lower, middle and upper Miocene age are widely distributed and at many places surpass the early Tertiary rocks in areal extent and thickness. Marine strata of Pliocene age generally are restricted to existing deep depositional basins and their closely adjacent margins. Thick accumulations of marine and nonmarine deposits of Pleistocene and Holocene age are preserved at places along the mainland coast and in the exterior basins.

3. Petroleum Source and Reservoir Horizons

Although little is known about the depositional history, lithology and stratigraphy of the rocks underlying the offshore area, many inferences can be drawn from the adjacent onshore region. Published descriptions of the rocks suggest that a number of the shaly or silty units ranging in age from late Cretaceous to late Miocene contain sufficient carbonaceous or other organic matter to constitute potential rocks for petroleum. Whether or not the deformational and thermal history of any of these units has been appropriate for the genesis and migrate of fluid hydrocarbons is not known. By analogy with onshore areas in the Ventura and Los Angeles Basins and offshore in the Santa Barbara Channel, one can presume that conditions may have been suitable.

Two of the units described from their outcrops on the northern Channel Islands are of particular interest as potential source rocks. Both are Miocene in age. They are the older Miocene Rincon Shale and the Middle Miocene Monterey Formation. From the lithologic descriptions of the Rincon Shale on the Channel Islands and from regional stratigraphic considerations, the older Miocene unit can be considered a likely source of fluid hydrocarbons wherever it has been subjected to burial at depths of only a few thousand feet. Some of the finer-grained portions of the Monterey Formation appear from descriptions and from regional considerations to constitute likely source beds.

Pliocene age sediments of unknown source-bed quality probably are restricted to the central parts of the basins where depths of burial are likely to be too shallow for the generation of petroleum.

Reservoir rock types in the Borderland are likely to be similar to those found onshore. Much of the onshore production is from Upper Miocene and Pliocene sands that were deposited in deep water in close proximity to adjacent source areas of high topographic relief. Similar deep-water sands of Cretaceous and older Tertiary age have much poorer reservoir quality because their original porosities have been reduced diagenetically by processes including time and greater depths of burial. Shallow-water and nonmarine sands are of secondary importance as reservoirs, even though they generally have better reservoir quality than their deep-water counterparts. These include the wide-spread sands of Early Miocene and Oligocene age.

Presumably any of these coarser grained sands, if present in the Borderland, could be potential reservoirs. Even Cretaceous and early

Tertiary sands, because their diagenetic history may be different than onshore, may have adequate reservoir porosities and permeabilities in the Borderland.

Fracture porosity in siliceous shales, cherts, and carbonates of Miocene age provides the reservoir space for hydrocarbons trapped in a number of oil accumulations in each of the major petroliferous basins in California. There is a good possibility that there are such accumulations in the Borderland.

For a description of Major Geomorphic and Bathymetric Features of the shallow portions of the continental shelf and its sediments and faults and folds refer to Appendix 10, A.2.3. and 4.

Fresh-Water Aquifers

An aquifer is a rock body that contains sufficient saturated permeable spaces to conduct ground water, or basically, any water-bearing formation. Along Southern California several aquifers have been identified in the Los Angeles and Orange County areas. Although these areas have been identified, to our knowledge there is no information available of their extent.

Recently U. S. Geological Survey (Marine Geology) completed a survey along the coast in the vicinity of Oxnard identifying aquifers which lie offshore. From this coastal survey the following five aquifers and their respective formation thicknesses were found: Grines Canyon - 460 m (1500 ft.), Fox Canyon - 180 m (590 ft.), Hueneme - 135 m (443 ft.), Mugu - 80 m (262 ft.) and Oxnard - 70 m (230 ft.). All of the above aquifers extend out to the east slope of the Santa Barbara Basin except for Grines Canyon aquifer which extends beneath the Santa Barbara Basin.

4. Geologic Hazards

The California Division of Mines and Geology (1973) has analyzed the major geologic hazards in California. They conclude that the greatest threat to lives and property is fire and collapsing due to violent ground shaking from earthquakes. Other hazards include: land-sliding, flooding, erosion activity, expansive soils, fault displacement, volcanic hazards, tsunami hazards and subsidence. For a further discussion of earthquakes and other geological hazards, see Appendix 10, A.5.

a. Earthquake Shaking

The largest losses of life and property in California due to geologic hazards have been caused by violent ground shaking during earthquakes. Earthquake shaking is largely due to the release of seismic energy during periods of sudden displacement along a fault. Since 1912 more than 25 damaging earthquakes have struck California, inflicting a total life loss of over 1,000 and property losses in excess of 1 billion in dollar values at the time of the earthquakes, or more than \$8 billion in 1974 dollar value.

The serious concern for earthquake shaking is reflected in California by a broad range of laws and codes that have been adopted at state and local levels. The Uniform Building Code, 1970 edition, contains a seismic zone map for the United States which categorizes the country into four zones:

Zone 0 -- No damage

Zone 1 -- Minor damage. Corresponds to intensities V and VI of the Modified Mercalli Scale

Zone 2 -- Moderate damage. Corresponds to VII on the Modified Mercalli Scale.

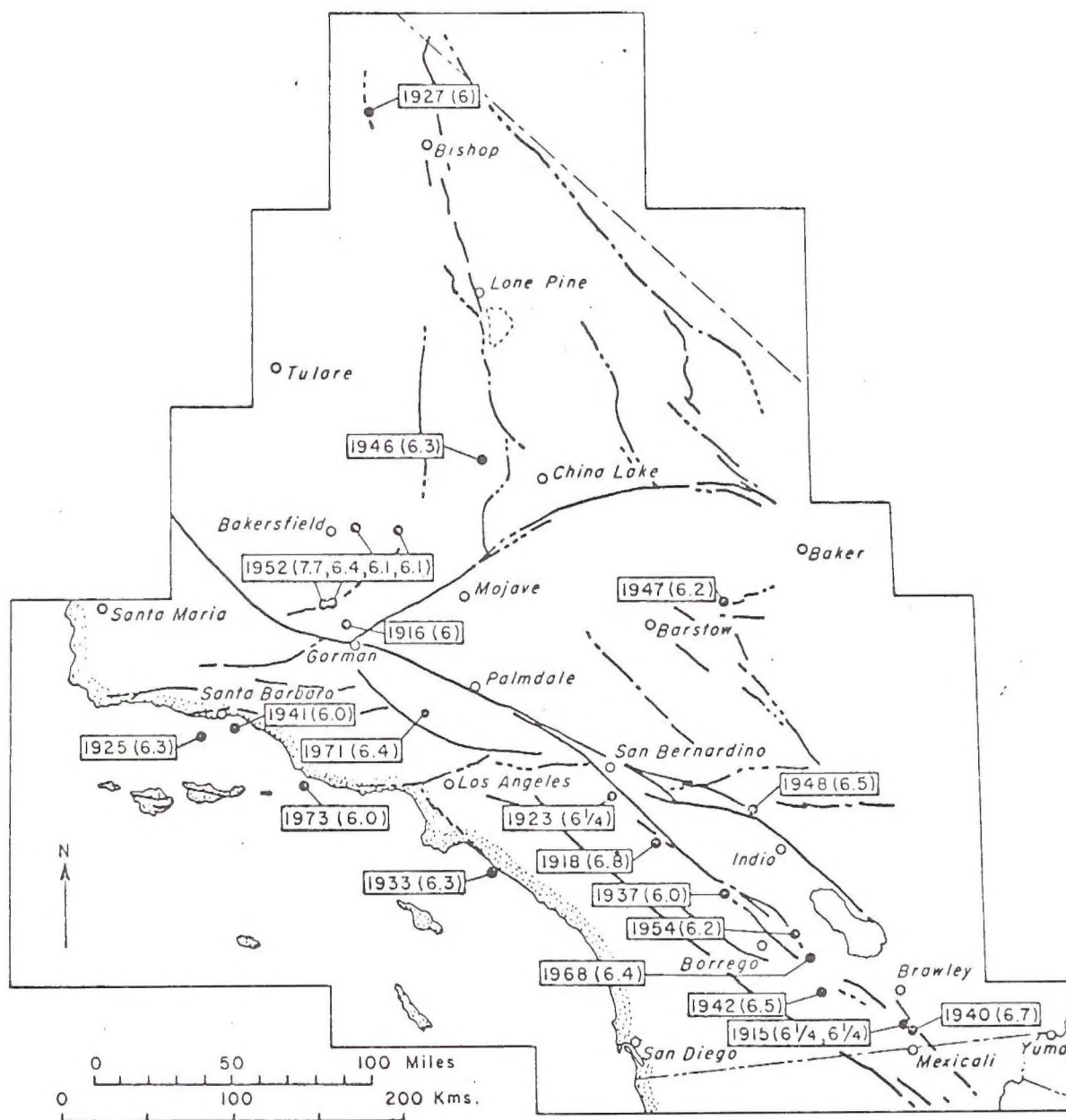
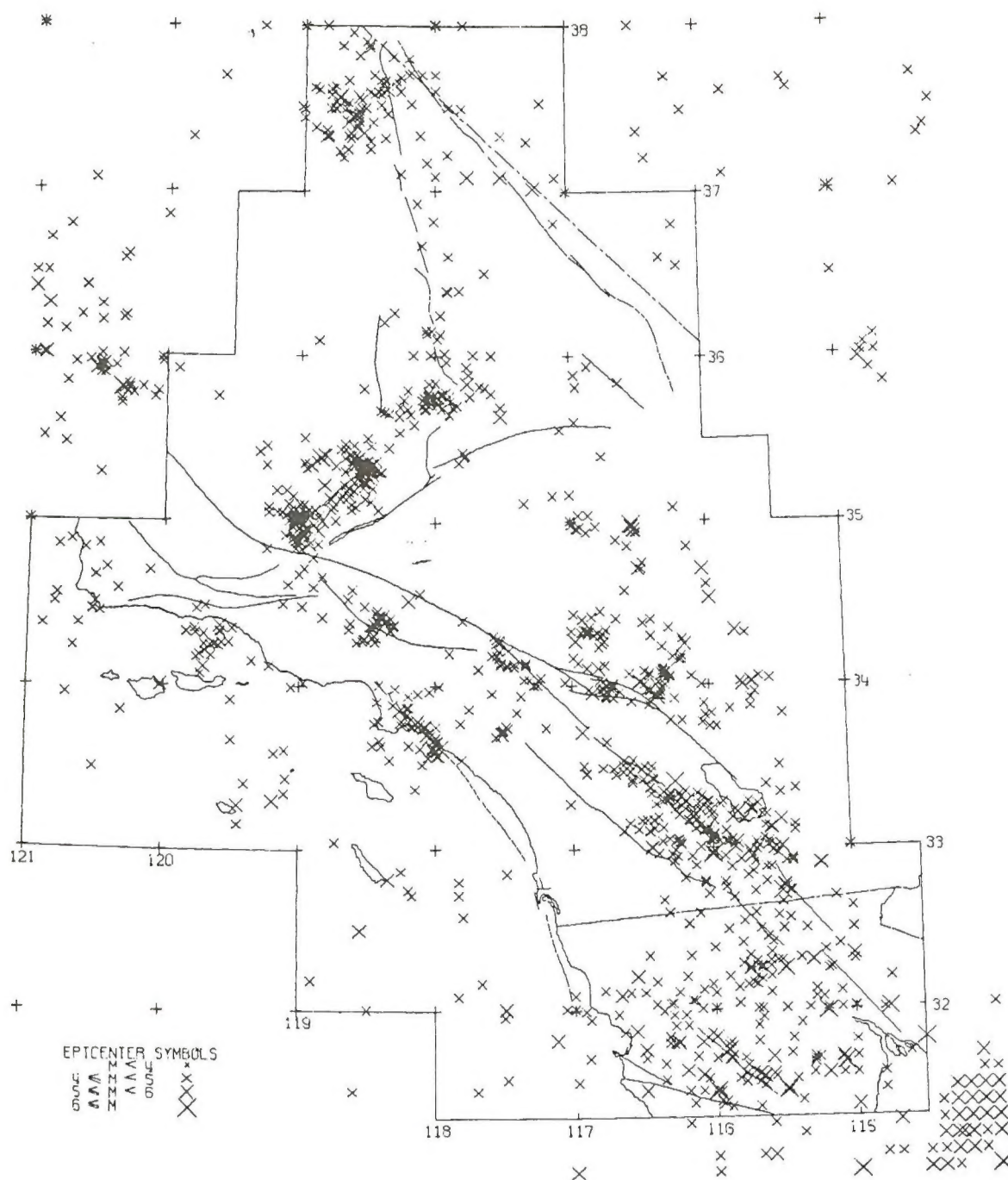
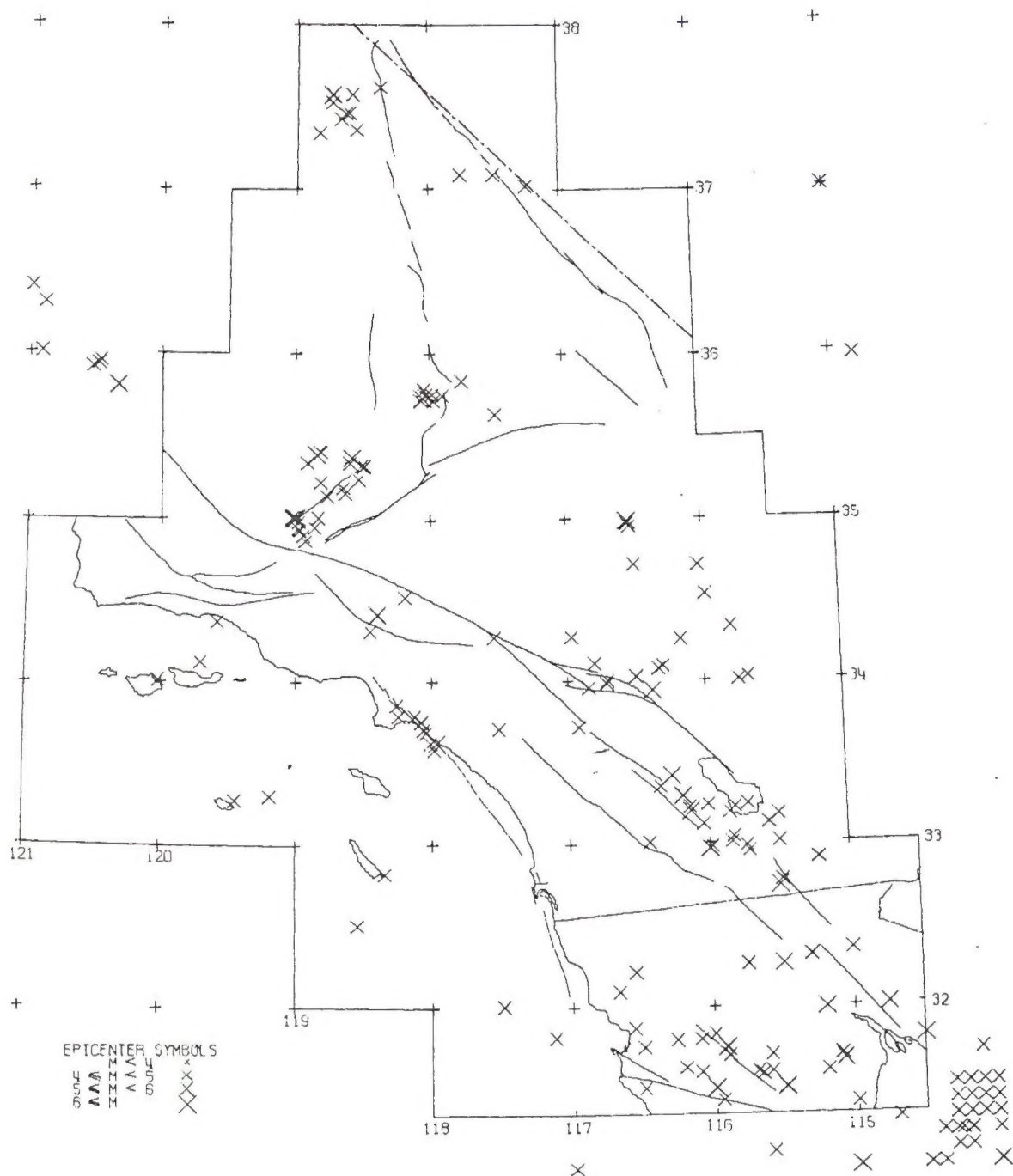


Figure II-5 Earthquakes of magnitude 6 and greater in Southern California since 1912. Modified from Allen and others, (1965).



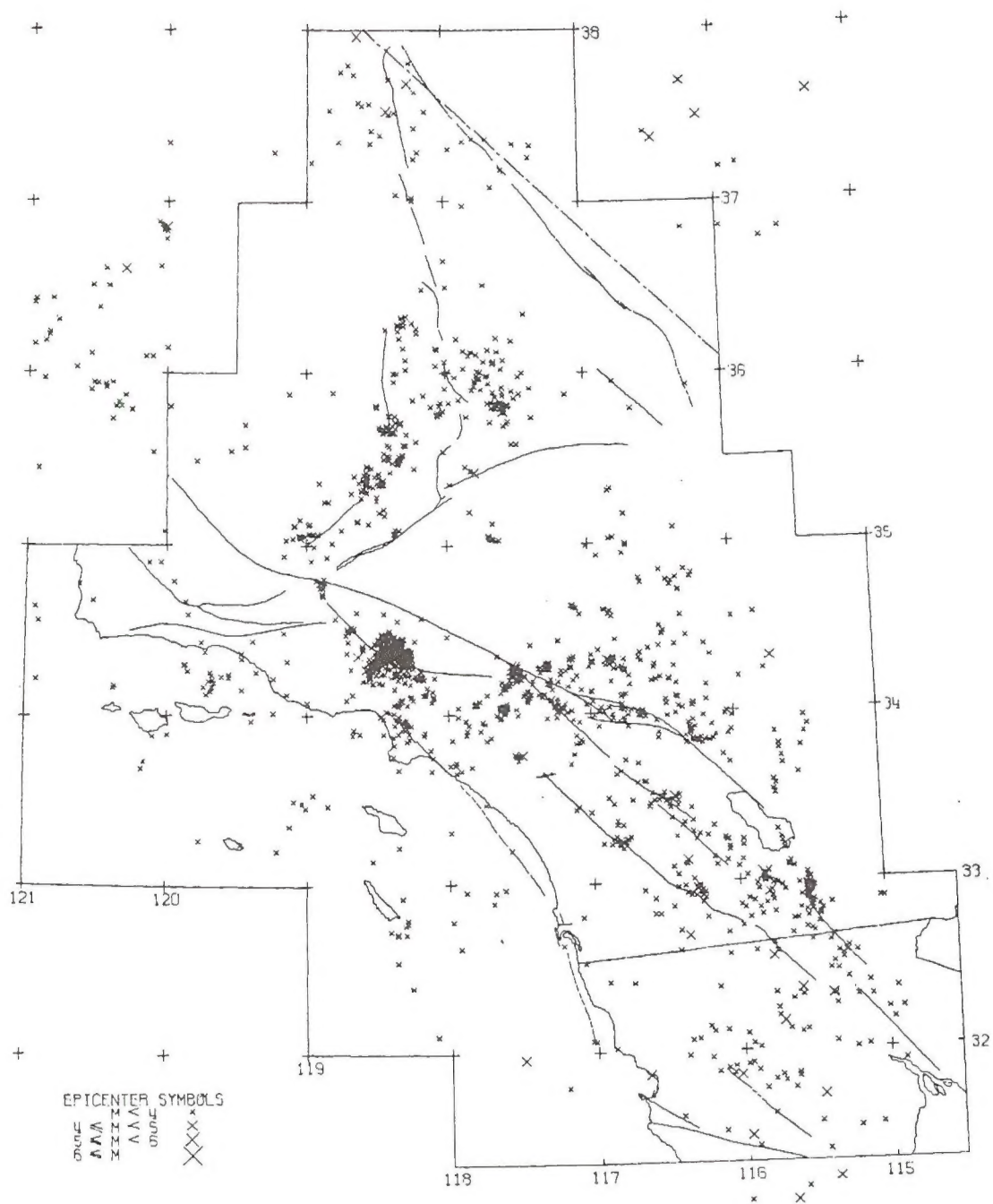
1932 THROUGH 1972, EVENTS EQUAL OR GREATER THAN MAGNITUDE-4 (Hileman et al. 1973)

Figure II-5a



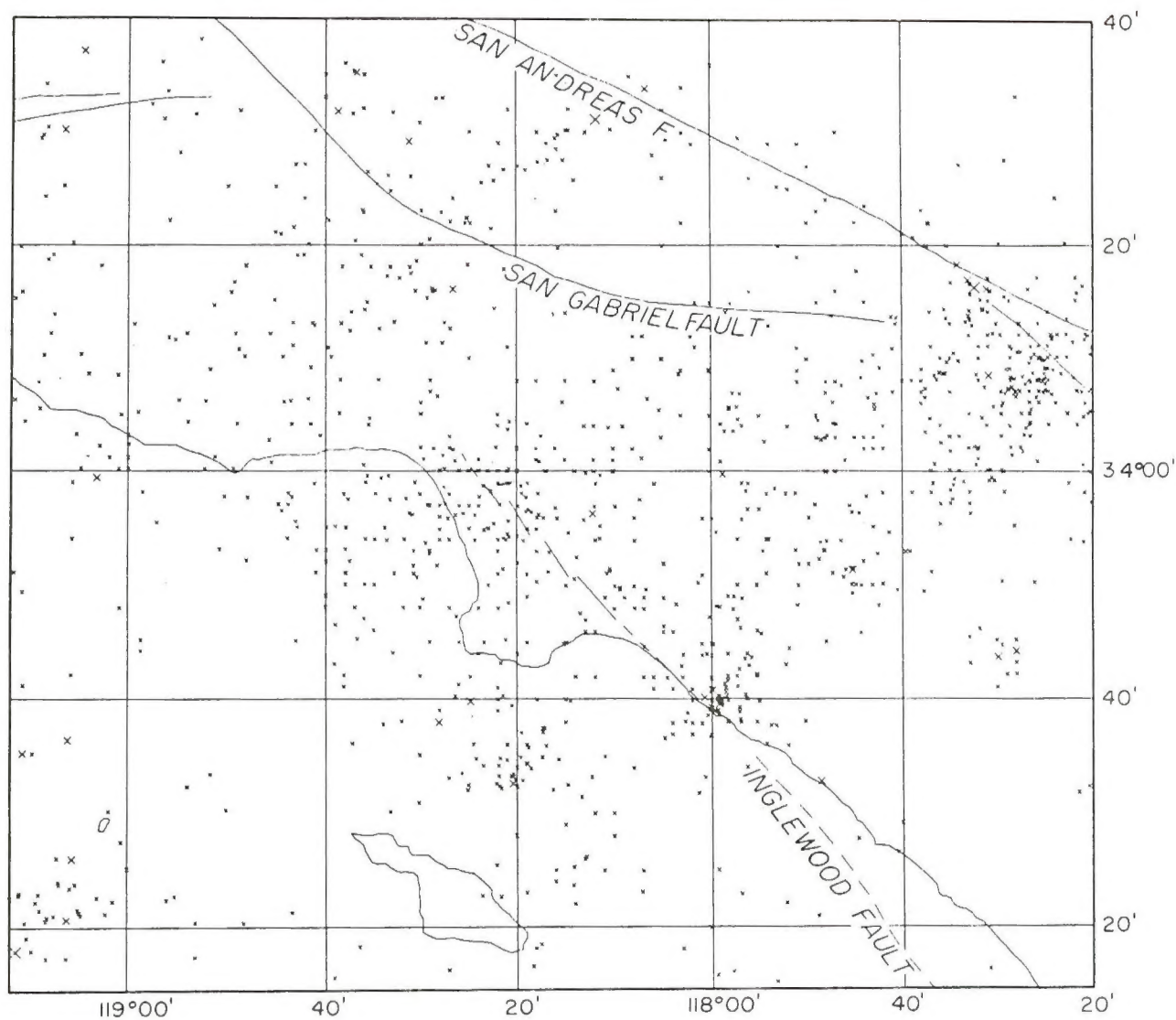
1932 THROUGH 1972, EVENTS EQUAL OR GREATER THAN MAGNITUDE-5 (Hileman et al. 1973)

Figure II-5b



ALL EVENTS 1970 THROUGH 1972 (Hileman, et al. 1973)

Figure II-5d

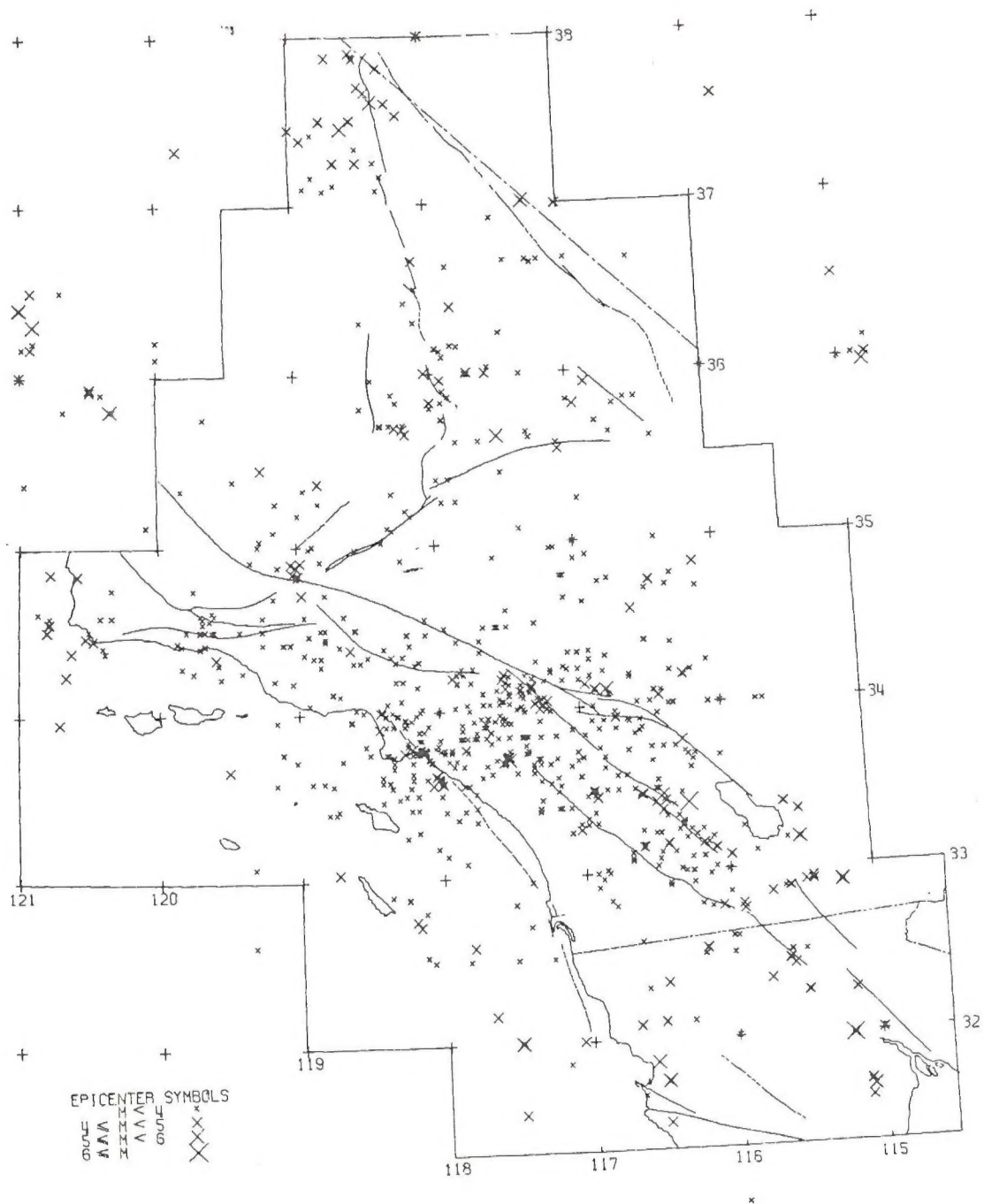


LOS ANGELES AREA, 1950 THROUGH 1970 (Hileman et al. 1973)

EPICENTER SYMBOLS

 x x x x x
 x x x x x
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Figure II-5e



1935 THROUGH 1939, ALL EVENTS (Hileman et al. 1973)

Figure II-5f

Zone 3 -- Major damage. Corresponds to VIII or higher on the Modified Mercalli Scale.

The Southern California Borderland lies entirely within Zone 2 and 3.

The Southern California Borderland is located within the circum-Pacific seismic and volcanic belt and has been tectonically active throughout much of Cenozoic time. This tectonism seems to have been accelerated during the latter part of this era, maximum activity having occurred in Quaternary time. One way of depicting the seismic setting of the Southern California Borderland in relation to the rest of Southern California is to show the distribution of recent earthquakes. Fig. II-5 shows all earthquakes since 1912 of magnitude 6 and greater. Figs. II-5a through II-5f depict a summary of events over specific years. Since 1912, more than 20 earthquakes of magnitude 6.0 or larger have occurred in Southern California. The San Jacinto fault zone, which trends southeast from San Bernardino and is part of the San Andreas fault system, was the site of eight of these shocks; four others occurred near Bakersfield during the Kern County earthquake sequence of 1952; and two were located in the Santa Barbara Channel. The 1927 earthquake, of magnitude 7.5, centered west of Point Arguello and should, perhaps, be grouped with the other two events in the Channel region because all three may have occurred on faults in the Transverse Range Province. The 1933 Long Beach earthquake with a magnitude greater than 6 had its epicenter near shore in San Pedro Bay.

An earthquake shook the Borderland on February 9, 1971. Its epicenter was about 14 km (9 miles) northeast of the city of San Fernando, the focus was 13 km (8 miles) beneath the surface and the magnitude was

6.4. Sixty-four persons lost their lives and tangible damage was estimated at \$443,000,000. Nearly 25,000 buildings were damaged or destroyed. Oil and gas installations in the Los Angeles area largely escaped severe damage (Oil and Gas Journal 1971). However, one small refinery located in Newhall, 11 km (8 miles) from the epicenter, was forced to shut down temporarily.

Operators of all Federal public and acquired land leases in Los Angeles and Ventura Counties were required by the USGS to report damage. Some of the leases are within 16 km (10 miles) of the epicenter, but there was no significant damage to the production facilities or producing wells in the 20 Federal leases from which reports were received. The relatively light damage sustained by petroleum production and refinery facilities was probably due to the geographic relationship of those facilities to the earthquake fault break. Although the Newhall refinery is almost the same distance from the epicenter as the most heavily damaged areas, the latter were located along the surface fault break. The greatest structural damage was concentrated in two areas: 1) along the surface rupture, in areas of locally amplified seismic shaking and 2) in tectonically deformed areas of the thrust plate, above the faults having surface rupture (USGS 1971 p. 75). The San Fernando earthquake clearly demonstrated the importance of recognizing the location of active fault scarps and the tectonic nature of movement on a fault system.

Teng and Henyey (1974) of the USC Geophysical Laboratory analyzed all the earthquakes with epicenters in the Greater Los Angeles area between January 1 and December 31, 1973. They reported 61 detectable earthquakes with the following distribution: 50 had magnitudes between

2.00 and 4.51, 8 had magnitudes less than 2.0, and 3 had no calculated magnitude. Seven of these were located in Santa Monica Bay, four were located in San Pedro Bay, and 50 were beyond the 500 m contour or in the eastern border of the Santa Barbara Channel.

Additional information is needed on which of the numerous Borderland faults are active. Certain faults, which are tied to earthquake epicenters, are assumed to be still deforming, but motion on the majority of faults is unknown.

Allen et al. (1964) found that for the portion of Southern California encompassing the region between Bishop and Ensenada, smaller earthquakes provide a fairly good estimate of the rate of occurrence of larger events. They calculate that on the average a magnitude 6.1 earthquake should occur each year in this region and a magnitude 8.0 earthquake should occur one in 52 years. A magnitude 8.0 earthquake, anywhere in Southern California, would probably have destructive effects in the Southern California Borderland.

b. Fault Displacement

Two aspects of fault displacement should be considered: 1) the effects that sudden displacement along faults may have on structures built across their traces and 2) the relatively slow effects of fault creep, the gradual ground distortion and movement along a fault trace not accompanied by significant earthquakes. The present state of the art is such that active faults can be identified and located through detailed geological mapping, seismic study, and other geophysical work. All proposed tracts contain faults. It is not known which of these faults are active and which are inactive. It would be necessary to run high resolution seismic profiles across any proposed site for a well or platform in order to determine the recency of activity.

c. Tsunamis

Tsunamis or seismic sea waves are large oceanic waves that are generated by earthquakes, submarine volcanic eruptions or large submarine landslides. The waves are formed in groups having great wave length and a long period. In deep water, wave heights (crest to trough) may be a few meters or less, wave lengths of a hundred miles or more and velocities greater than 400 knots (460 mph). As a tsunami enters shallower waters, wave velocity diminishes and height increases. Waves can crest at heights of more than 30 m (100 feet) and strike with devastating force. The largest tsunami ever reported in California followed the 1812 earthquake. The wave may have reached land elevations of 15 m (50 ft.) at Gaviota and 9. - 10.6 (30-35) at Santa Barbara.

The eastward curvature of the coast, starting at Point Conception, provides some sheltering effect from tsunamis originating in the north Pacific region. Tsunamis originating in the southern or central Pacific would enter the Bight directly, although some protection would be afforded the mainland shore by the islands (Fig. II-6a).

d. Subsidence

Subsidence of the land surface, as a result of the activities of man, has been occurring in California for many years. Subsidence can be divided, on the basis of causative mechanisms, into four types: groundwater withdrawal subsidence, oil or gas withdrawal subsidence, hydrocompaction subsidence, and peat oxidation subsidence. The distribution of the four types of subsidence in California is shown in Figure II-6b. Oil and gas withdrawal subsidence is the only one of the four types that will be treated in detail here. Ground-water subsidence is briefly discussed.

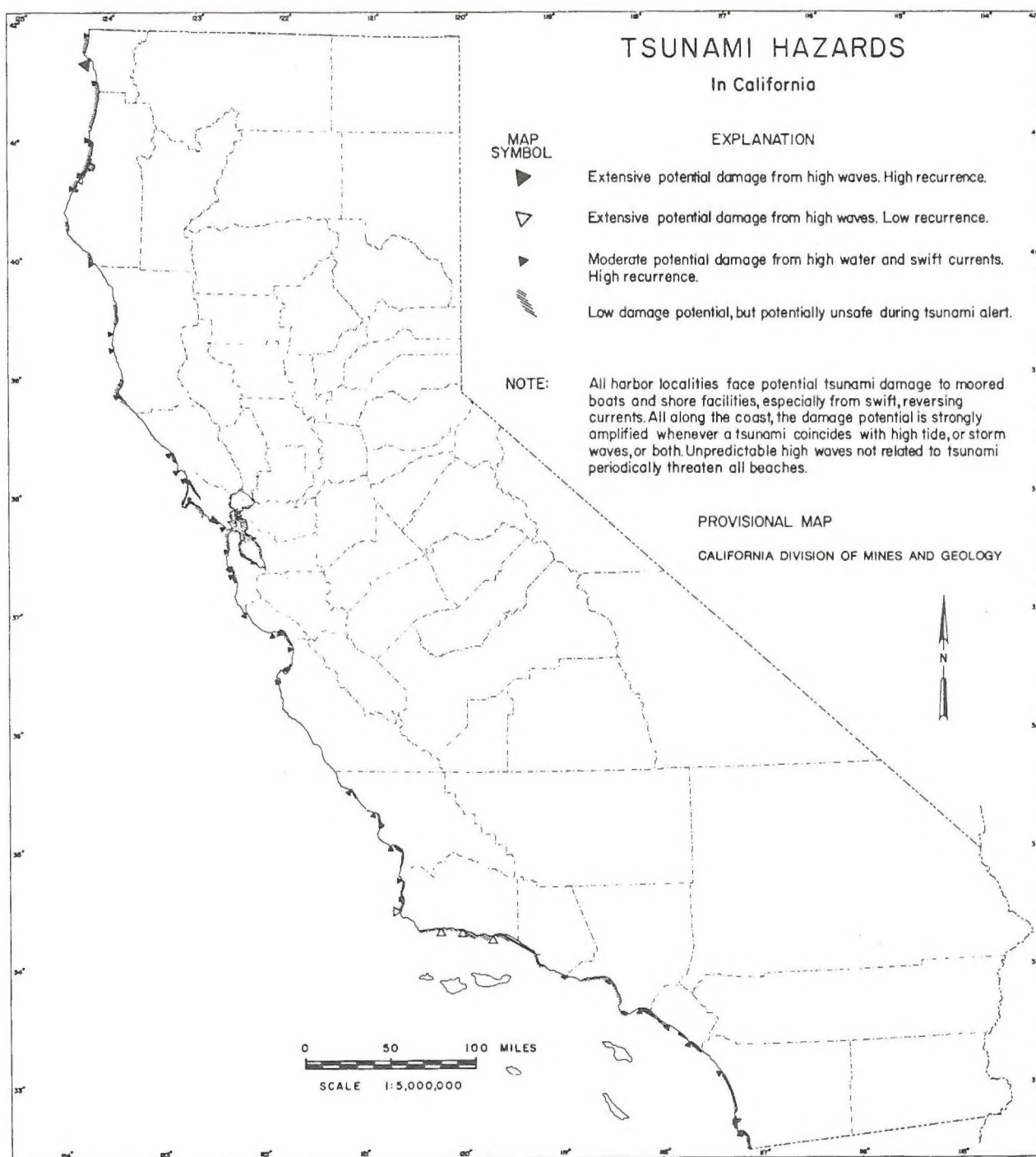


Figure II-6a Tsunami Hazards in California (California Division of Mines and Geology, 1973).

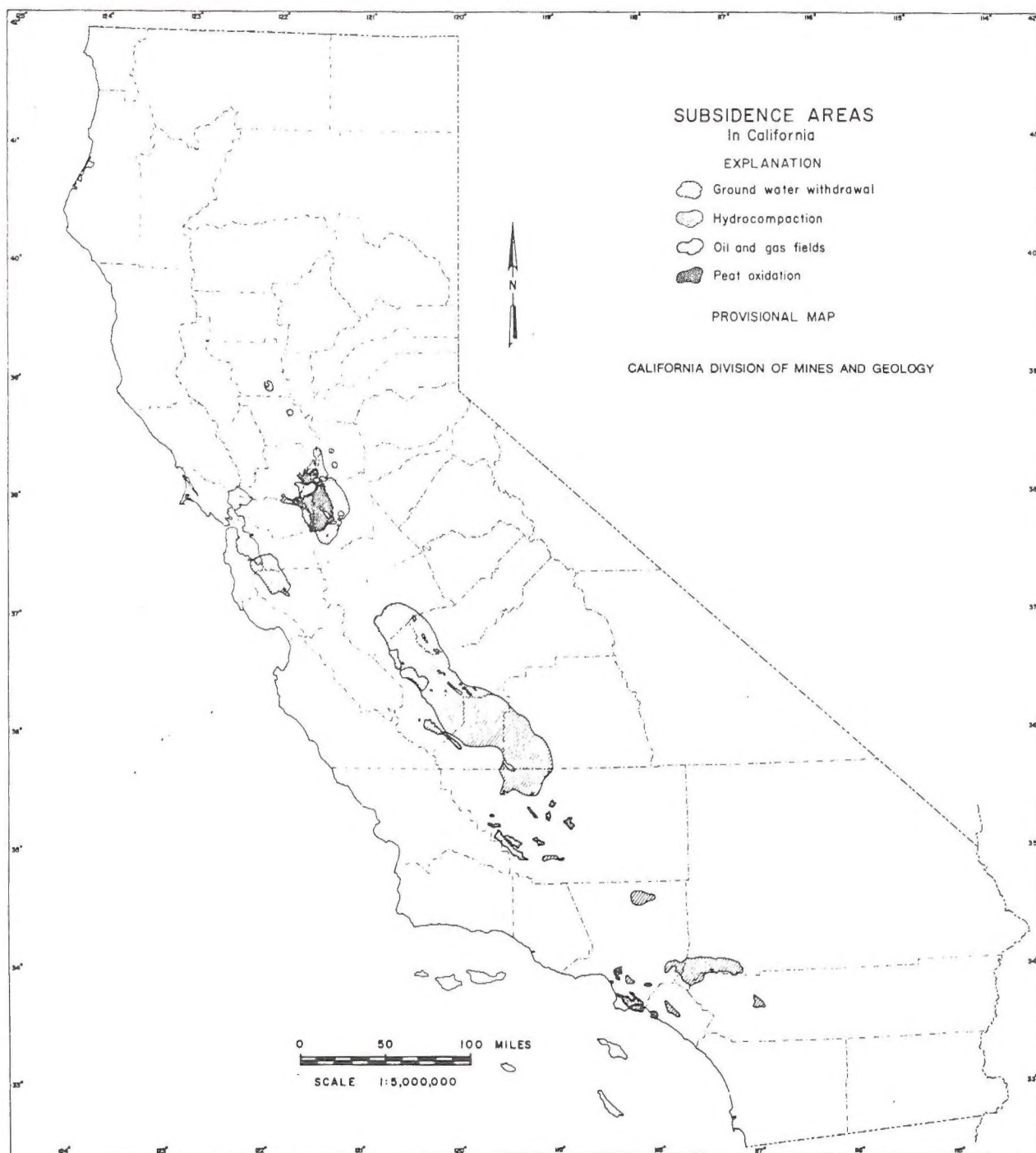


Figure II-6b Subsidence areas in California (California Division of Mines and Geology, 1973).

Twenty-two oil and gas fields in California are known to have experienced subsidence. The better documented of these fields are located in the Los Angeles basin where considerable damage has occurred to works of man. The most dramatic example of subsidence damage has taken place in the Wilmington field near Long Beach.

The area that subsided over the Wilmington field is intensively industrialized and initially was only 1.5 to 3.0 meters (5 to 10 ft.) above sea level. By 1966, subsidence had placed much of the area well below sea level and extensive construction of dikes and raising of dock facilities was required. Surface deformation within the subsidence bowl had caused extensive damage to pipelines, oil field equipment, railroad tracks, and buildings. Total horizontal displacement at Wilmington affected an area roughly 4450 m (14,600 ft.) by 6100 m (20,000 ft.) with 2 or more feet (0.6 m) of movement during the period of 1937 to 1970. Maximum displacement near bowl's center equalled 3.66 m (12 ft.). Vertical displacement affected an area approximately 10,800 m (35,300 ft.) by 6300 m (20,700 ft.) with subsidence varying from 0.6 m (2 ft.) to 8.8 m (29.0 ft.).

Surface deformation, associated with oil and gas field operations in California, has manifested itself in differential subsidence of lands centering on the fields, inwardly directed horizontal displacements, and faulting. Twenty-two fields have experienced differential movement, three have experienced horizontal subsidence, and five have experienced faulting (Yerkes and Castle, 1969). Significant subsidence (that which is loosely defined as exceeding 30 cm (1 ft.) is relatively uncommon.

Differential subsidence is the most common and widespread of the surface effects. Subsidence centers over and extends well beyond the producing areas and frequently takes the shape of a bowl. Large subsidence bowls have been documented over the Wilmington field, the Huntington Beach field, the Long Beach field, and the Inglewood field.

Subsidence of the land surface, as a result of the withdrawal of oil and gas, occurs in much the same way as does subsidence in groundwater withdrawal. That is, as pore pressures are reduced in reservoirs by fluid withdrawal, the overburden load is gradually transferred from the fluid to the reservoir rock and when poorly consolidated the sediments are compacted.

Before oil field subsidence can occur: 1) pore fluid pressure must be reduced, 2) reservoir rocks must be compactable and unable to resist deformation when loading transfers from the fluid to intergranular structure, 3) and the overburden must be incapable of self-support and deformable downward so as to impose a constant load on underlying formations.

With falling pore fluid pressures, load transfer to the formation's framework occurs. If adequate concentration of grains does not exist, compaction will occur by sand grain rearrangement, grain crushing, fractures of sharp corners and through plastic flow of clays and micas. Interbedded shales, siltstones and clays will also be exposed to pressure gradients and tend to dewater into the reservoir (Allen, 1973).

Unconsolidated sandstones were found to compact as much as 5 to 7 porosity percent with loadings ranging from a few hundred psi to a few thousand psi (Von der Knapp and Van der Vlis, 1967; Allen and Mayuga,

1969; Roberts, 1969; Sawabini et al., 1972; and Newman, 1973; in Allen, 1973).

Structure has an influence on the occurrence of subsidence through its ability to resist deflection of the overlying beds. Sharp folds function much as an arch in resisting downward deformation while broad folds exhibit inherently less strength. Unrelieved tectonic stresses affect the resistance of structure to deformation. Subsidence is less likely to occur where flank dips are greater than 25° on narrow or tight folds. The likelihood is further reduced if associated faulting is high angle or reverse indicating compressive stress.

A reservoir width/depth relationship is important particularly as it affects the beam or slab effect of overlying structure. Compressive stress adds to the resistance to deformation in this situation also.

Subsidence appears to be related to reservoir pressure drop rather than directly to fluid production.

Allen et al., (1971) have accumulated the following list of factors common to areas of fluid extraction induced subsidence:

- 1) Generally, sand reservoirs with a thick vertical section.
- 2) The sands are unconsolidated and lack cementation.
- 3) Porosities of 25-40%.
- 4) Reservoir sands are interbedded with siltstones, shales, etc.
- 5) Large fluid production.
- 6) Large drops in fluid levels.

Subsiding oil producing reservoirs have the additional common features:

- 1) Relatively shallow burial (top of uppermost zone is less than 3,000 feet $\pm$) (915 m).

- 2) The overburden is composed of unconsolidated sediments.
- 3) Reservoir beds have gentle dips at the structure crest.
- 4) Tension faulting common, graben blocks formed.
- 5) Miocene and younger ages.
- 6) Subsidence is associated with the oil field development by location and by time of occurrence.

Subsiding water producing areas have these additional common features:

- 1) Shallow, flat-lying aquifers covering large areas.
- 2) Subsidence rate is cyclic and controlled partially by seasonal fluid level fluctuations.
- 3) Pliocene and younger ages.

While none of the listed items were regarded as mandatory, a preponderance of them was considered to indicate subsidence susceptibility. Even in the presence of many of these factors, subsidence fails to occur most likely because of the supportive ability of the overlying strata. These overlying strata, particularly when in compression, may exert considerable resistance to bending or fracture.

In the case of oil fields, magnitudes of subsidence may be comparable to those found in circumstances of groundwater withdrawal. The greatest documented subsidence in the world has occurred at Wilmington oil field where a maximum of 8.8 m (29 ft.) of subsidence was reported to 1966, when subsidence was halted at Wilmington by repressurization in conjunction with the secondary recovery of oil. Subsidence, in an area 54 kilometers (40 miles) west of Fresno along the west sides of San Joaquin Valley, may soon exceed the Wilmington area record. In this area of the San Joaquin Valley, subsidence due to ground water withdrawal was recorded to have reached a maximum of 8.5 meter (28 ft.) by 1969.

Subsidence due to gas withdrawal alone apparently does not reach magnitudes comparable to oil and ground water withdrawal subsidence. Perhaps for this reason subsidence due to gas withdrawal is not widely recognized, and if subsidence is detected over a gas field, separation from other types of subsidence, which may be going on concurrently, may be difficult.

The effects of subsidence are varied and sometimes seemingly anti-thetic. For example, in the Wilmington oil field, casing protruded from the ground, failed in tension, and twisted. The variability is attributable to where the casing is cemented in relation to the subsiding strata. Regional tilting can develop with sufficient subsidence as elevational changes may vary from zero at the edge of the bowl to the maximum loss in elevation near its center. Folding or scarping may develop in hard sediments or where the field is fault bounded. The Goose Creek field in Texas developed 46 cm (18 in.) scarps after subsidence of approximately 1.8 m (6 ft.). At Wilmington, pipeline damage began when subsidence reached 1.8 m (6 ft.) and the first earthquake occurred at that point.

Monitoring systems can detect subsidence with sufficient precision to commerce counteraction before the onset of deleterious effects. Detection is affected by simple leveling methods, collar and radioactive bullet logging, extensometer compaction recorders, trilateration nets, seismic monitoring and reservoir pressure surveys (Allen, 1973).

Pressure injection of water can arrest subsidence. At Wilmington, subsidence has not only been stopped, but rebound has begun to occur. In the 4 years since repressurization was initiated at Wilmington in 1966, vertical rebound near the bowl's center was 24 cm (0.8 ft.) and horizontal recovery equalled 27 cm (0.9 ft.).

Subsidence potential is difficult to predict without the kind of information derived from field development activities. Some generalizations can be made, however. Of the proposed sale area, that portion of San Pedro Bay shoreward of the Palos Verdes Fault Zone, is most similar to the Wilmington field area. Here is a thick section of Miocene-Pliocene strata which are likely to be poorly consolidated and more apt to undergo subsidence. Control of subsidence is demonstrated at Wilmington under similar circumstances and should present no problem.

Elsewhere, in Santa Monica Bay, and the Outer Banks, and seaward of the Palos Verdes Fault Zone in San Pedro Bay, sections are thinner and denser than the aforementioned area and are consequently less susceptible to subsidence.

Subsidence can be adequately detected and arrested or reversed, so it is not expected to constitute an environmental hazard.

e. Hydrocarbon Seeps

Many large surface exposures of viscous tar exist in Santa Barbara and Ventura counties and on the offshore islands. In addition large pools of tar have existed for much of the last 40,000 years at Rancho La Brea in Los Angeles County. The age of

first appearance of these natural seeps is unknown, but the seeps may owe their origin to the late Pleistocene folding described previously. Archeological evidence indicates that California Indians used tar from surface seeps to waterproof canoes, jugs and baskets. Dates associated with these cultures are 7,000 years and older.

Consequently, much evidence exists to confirm that tar on Southern California beaches is not the exclusive result of offshore petroleum operations. In fact, Spanish explorers as early as the 1770's had observed tar on the beach near Goleta (Heizer, 1943).

Seeps occur offshore too. All of the active oil and gas seeps that are known to occur offshore have been found between Point Conception in Santa Barbara County and Huntington Beach in Orange County (Table II-1). However, the largest concentration of seeps appears to be in the Santa Barbara Channel area.

Where submarine observation is possible, the position of seeps may be accurately fixed, but restricted underwater visibility combined with the intermittent or varied flow of most seeps often makes visual contact with seep vents difficult. Some seeps apparently remain dormant for extended periods of time and then are reactivated by either a pressure build-up, or perhaps, earth movement. Because of the transient nature of many seeps, an accurate count is difficult to obtain. However, it appears that there are probably between 50 and 60 offshore oil and gas seeps or seep areas between Point Conception, in Santa Barbara County, and Huntington Beach in Orange County (Calif. Div. of Oil and Gas, 1972).

TABLE II-1
CATALOG OF OIL AND GAS SEEPS*

LOCATION	Lat. & Long.	References	Remarks
1. Coronado	32° 28'20"N 117° 21'30"W	Oil Age, 1923	Questionable - May be a spill
2. Catalina, west end	33° 28'20"N 118° 36'50"W	Western Oil & Gas Assoc., 1931	½-acre oil slick sighted from steamer, 1923 Frequently sighted by fishermen; now inactive
3. Catalina, west end	33° 29'10"N 118° 36'30"W	See 2	See 2
4. San Pedro Channel	33° 35'40"N 118° 20'30"W	U.S. Bureau of Mines, 1923 Calif. Academy of Science, 1917	Oil droplets & slabs of tar as large as 8"x5"x1"
5. Huntington Beach	33° 40'10"N 118° 01'50"W	Signal Oil and Gas Co.	Gas bubbles from outcrop, probably of marsh gas sands
6. Palos Verdes	33° 48'10"N 118° 24'40"W		
7. Redondo Beach	33° 49'00"N 118° 26'10"W	U.S. Bureau of Mines, 1923	Oil and gas, about 3.5% sulfur Intermittent flow in 1927; no estimate made Oil slick about 50 acres in 1928
8. Redondo Beach	33° 50'10"N 118° 25'30"W	University of Southern California	Oil and gas On line of Palos Verdes fault
9. Manhattan Beach	33° 52'10"N 118° 27'40"W	Seismological Soc. America, 1920 Standard Oil Co. of California and W. T. Knowlton, 1928	Oil and gas, about 4% sulfur 9 & 10 together estimated to be discharging about 10 barrels of oil per day in 1928 200- to 400- acre oil slick On line of Palos Verdes fault
10. Manhattan Beach	33° 52'20"N 118° 29'20"W	See 9	See 9
11. San Miguel Island	34° 04'30"N 120° 25'20"W	Western Oil & Gas Assoc., 1931 Oil and Gas Journal, 1937	First noted by U.S. Coast & Geodetic Survey in 1875 Oil and gas Mostly tar
12. Santa Cruz Island	34° 03'20"N 119° 54'10"W	Papers written about the island in French in 1893 and translated by Dr. Redwine, Union Oil Co. Emery, 1960	Mostly tar
13. Santa Cruz Island	34° 00'40"N 119° 53'40"W		
14. Santa Barbara Channel	34° 02'20"N 119° 16'10"W	Emery, 1960	Discovered by continuous presence of oil, gas bubbles, and tar on the water
15. Santa Barbara Channel	34° 08'00"N 119° 41'24"W	Standard Oil Co. of California	See 14
16. Platform A	34° 20'20"N 119° 36'30"W	Lewis & Lewis (surveyors for Union Oil Co.), 1968	Discovered before platform was installed about 800 feet from platform Oil and gas from saturated shale outcrop
17. Platform Houchin	34° 20'00"N 119° 33'40"W	U.S. Geological Survey	
18. Platform Heidi	34° 21'00"N 119° 30'20"W	Mattei, 1929, in Santa Barbara newspaper	On crest of anticline
19. Rincon Trend	34° 21'30"N 119° 29'40"W	L. S. Fox, 1930	Gas bubbles from crest of anticline
20. Rincon Point	34° 22'50"N 119° 29'30"W	Whitney, 1865	From fractured Monterey Formation
21. Carpinteria	34° 23'30"N 119° 31'20"W	Father Crespi, 1770	Gas bubbles
22. Carpinteria	34° 23'40"N 119° 32'10"W	Father Crespi, 1770	Similar to seeps on shore
23. Montecito	34° 25'00"N 119° 38'00"W	Calif. Div. Mines Bull. 118	Probably on a fault
24. Montecito	34° 25'00"N 119° 38'30"W	Calif. Div. Mines Bull. 118	See 23
25. La Mesa	34° 21'40"N 119° 44'30"W	Standard Oil Co. of Calif.	
26. Hope Ranch	34° 22'00"N 119° 46'20"W	Standard Oil Co. of Calif.	
27. Hope Ranch	34° 24'20"N 119° 45'50"W	Standard Oil Co. of Calif.	
28. Coal Oil Point	34° 23'40"N 119° 51'40"W	Father Pedro Font, 1775 Sixth Annual Report, State of Calif. Mineralogist, 1886 Allen & Schleuter, 1969	Best known seep area Oil, gas and tar. Oil is 12.4 gravity Typically, oil is released as globules from sand patches, some of which are in line and some of which are independent Estimated discharge for area: Max. 160 bbls. oil per day Min. 11 bbls. oil per day Avg. 50-70 bbls. oil per day More than induced seeps at Platform A
29. Coal Oil Point	34° 24'00"N 119° 52'40"W	See 28	See 28
30. Coal Oil Point	34° 24'30"N 119° 52'00"W	See 28 J. Eaton, geologist, 1931	See 28
31. Platform Holly	34° 24'30"N 119° 54'40"W	Sixth Annual Report, State of Calif. Mineralogist, 1886	Probably similar to Coal Oil Point

TABLE II-1 (Cont'd)

CATALOG OF OIL AND GAS SEEPS

LOCATION	Lat. & Long.	References	Remarks
32. Naples	34° 25'30"N 119° 57'30"W	Holder, 1910	Tar in shale
33. Capitan Beach	34° 27'20"N 120° 00'30"W	Holder, 1910 Standard Oil Co. of Calif.	At intersection of faults
34. Refugio	34° 26'00"N 120° 03'30"W	Holder, 1910	Probably from Monterey Formation Oil slicks noted on water
35. Molino	34° 28'00"N 120° 09'20"W	Holder, 1910 Standard Oil Co. of Calif.	See 34
36. Gaviota	34° 27'30"N 120° 13'30"W	Holder, 1910 Standard Oil Co. of Calif.	See 34
37. Platform Helen	34° 26'50"N 120° 17'00"W	Standard Oil Co. of Calif.	Faulted area
38. Cuarta	34° 27'30"N 120° 17'30"W	Standard Oil Co. of Calif. Emery, 1960	Faulted area
39. San Augustine	34° 26'40"N 120° 20'30"W	Union Oil Co. of Calif. Emery, 1960	
40. Platform Herman	34° 26'00"N 120° 22'20"W	Union Oil Co. of Calif. Emery, 1960	
41. Cojo	34° 27'20"N 120° 24'30"W	Standard Oil Co. of Calif. Emery, 1960	Fractured shale on faulted anticline
42. Point Conception	34° 26'20"N 120° 26'50"W	Standard Oil Co. of Calif. Emery, 1960	Fractured shale on faulted anticline
43. Point Conception	34° 26'40"N 120° 28'30"W	Mattei, 1929 Standard Oil Co. of Calif.	Oil, gas and sulfur water seeps onshore Globs of tar more than 1 ft. in diameter Type of tar indicates seepage from Monterey Formation
44. Point Conception	34° 28'00"N 120° 29'00"W	See 43	See 43
45. Santa Barbara Channel	34° 06'40"N 120° 23'04"W	J. Stearns, 1969	Oil slick sighted from air Location approximate
46. Platform Holly	34° 23'30"N 119° 55'00"W	Atlantic Richfield Co.	
47. Platform Holly	34° 23'30"N 119° 55'10"W	Atlantic Richfield Co.	First observed in 1969 Discharge less than 1 bbl. oil per day at present
48. Platform A	34° 20'20"N 119° 36'30"W	U.S. Geol. Survey Prof. Paper 679	
49. Point Dume	33° 59'10"N 118° 46'20"W	Standard Oil Co. of Calif.	At 50 fm. contour on line between Pt. Dume & Pt. Vicente
50. White's Point	33° 42'50"N 118° 19'10"W	Emery, 1960 Standard Oil Co. of Calif.	Analyzed by Atlantic Richfield Co.
51. Hermosa Beach	33° 51'27"N 118° 28'10"W	Standard Oil Co. of Calif.	Oil seep
52. El Segundo	33° 53'35"N 118° 32'55"W	Standard Oil Co. of Calif.	Oil seep
53. Venice	33° 55'05"N 118° 35'05"W	Standard Oil Co. of Calif.	Oil seep
54. Platform Heidi	34° 20'30"N 119° 30'45"W	Calif. Div. of Oil and Gas	Gas bubbles

*California Division of Oil and Gas, 1972

Seeps seem to correlate with structural trends consisting of anticlinal axes and faults. Location of hydrocarbon seeps also shows a definite relationship to Late Quarternary unconsolidated sediment thickness. Fischer and Stevenson (1973) found that one-half of 900 mapped seepage occurrences were in areas covered with less than 1.5 meters (5 ft.) of unconsolidated sediment. They found that when sediment thickness exceeded 6 meters (20 ft.) seep frequency decreased to less than 5 percent. Source or reservoir horizons which are open to the sea bottom may also be seepage sources.

Between 1946 and 1972, there has been a notable reduction in seep activity in the Coil Oil Point area. Production of hydrocarbons from the Rincon-South Ellwood-trend began in this interval causing postulation that reduction in reservoir pressures caused decreased natural seep activity (Fischer and Stevenson, 1973). No chemical or structural evidence has demonstrated a connection between the seep hydrocarbons and those being produced from nearby fields. On the contrary, evidence indicates no relationship whatever. Others thus speculate that variability in sampling conditions combined with the seeps' natural variability account for the apparent decline (State Lands Commission, 1974).

The fate of seep oils, particularly the denser fractions emitting from vents at depths greater than 18 meters (60 ft.), is disposition in the deep Santa Barbara Basin (Fischer and Stevenson, 1973); while that from sources shallower than 18 meters (60 ft.) tends to wind up on nearby beaches. Volatilization, biodegradation and dissolution into the water column accounts for the remainder.

SOUTHERN CALIFORNIA PHOSPHORITE DEPOSITS

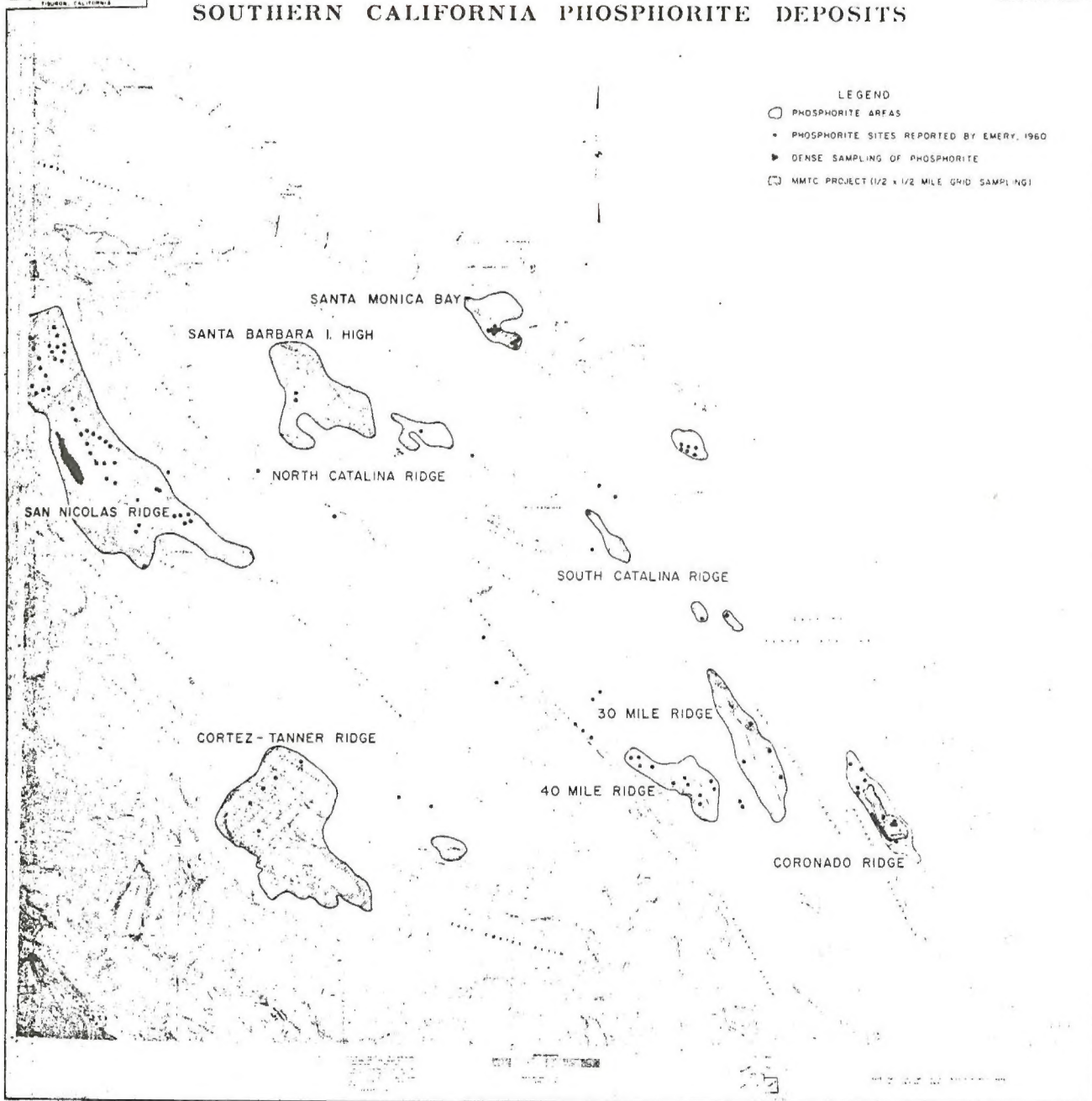


Figure II-7 Southern California Phosphorite Deposits (Barnes, 1970)

As interest in the offshore grows and exploration increases in the Outer Continental Shelf and Santa Rosa-Cortes Ridge region other oil seep locations will be identified. However, there has been no published documentation of any oil or gas seeps found in these areas as yet, but numerous oil and gas seeps have been visible.

f. Over pressured zones in the subsurface

Generally these zones have to be located by drilling. Gas zones which are potential blow out hazards may be detected by seismic data which shows gas charged sediment cones and gas seeps. "Bright spot" processing of seismic data may indicate deeper gas zones.

5. Offshore Minerals

The following discussion was primarily from Veder (1974) and DEIS comments from USGS and the Director of the Bureau of Mines.

a. Phosphorite

Phosphate-rich material is abundantly distributed in the Borderland area, but varies widely in concentration and quality. Figure II-7 shows the distribution of phosphorite deposits in the Southern California offshore area. The samples are composed of three major types: phosphorite nodules, phosphorite pellets and sands, and phosphatic bedrock in Miocene strata. Mero (1967) estimated that more than 900 million metric tons of phosphatic nodules are present on the seafloor off Southern California. Of these, he stated that 90 million metric tons may be of economic interest. A more recent estimate based on all phosphorite samples collected in this region (Inderbitzen et al., 1970) indicates the presence in a few areas of only about 45 million metric tons of phosphatic nodules and 11 million metric tons of phosphatic pellets, both types being of marginal grade. The remainder of the phosphatic material probably consists of thinly scattered nodules too sparse for recovery. Concerning quality, Barnes (1970) reported 26 percent maximum P_2O_5 content of 67 selected

phosphate-rich nodules, and Pasho (1972) reported a maximum P_2O_5 content of 36.8 percent from 53 selected samples. These samples compare favorably with the average onshore minable P_2O_5 content of 31 to 36 percent. However, the average P_2O_5 content of nodules dredged off Southern California is actually much lower grade, as demonstrated by a recent study by Barnes (1970) in the Coronado Bank area. This study shows that 85 percent of the samples assayed showed less than 1.0 percent P_2O_5 and that the average content of all the samples was only 3.3 percent. Coronado Bank, as well as Thirtymile and Fortymile Banks, was also prospected by the ocean mining industry with disappointing results, in the mid-1960's at depths of 60 to 1,500 ft. (18 to 365 meters) of water. Sorensen and Mead (1970) indicated that although many samples have been recovered from this area, we know little about the quality and quantity of phosphorite off the coast. They concluded that the quality and quantity of phosphorite off Southern California were too low to warrant commercial exploitation in the foreseeable future. Little further interest has been expressed in the offshore phosphorite deposits, but changes in economic conditions or market demands could alter this situation. Requests to lease OCS areas for phosphorite have been made and are still viable.

Phosphorite, both onland and offshore, usually contains small but important metallic impurities, such as vanadium, uranium, and rare earth elements bound up in the crystal lattice of the phosphate mineral, carbonate-fluorapatite. These constituents might be extracted as by products in the future, if commercial processes are developed. The amounts of vanadium, uranium, and rare earth elements contained in the borderland phosphorite have not been investigated.

The geologic occurrence of phosphate-rich rocks off Southern California involves many environments ranging from bank tops to outer shelf and upper slope areas. Offshore phosphorites were first recognized in 1937 among samples dredged from the tops of submarine banks (Dietz and others, 1942). Subsequent sampling has extended the range of occurrence in the California Borderland to the outer shelf, upper slope, flanks of banks, and tops of ridges and seamount areas. Appreciable accumulations of phosphorite nodules occur in topographic depressions and well down the slopes of ridges. Water depth seems to exert little, if any, control on nodule or pellet formation and they are found at depths greater than 11,000 feet (3,355 m).

Radiometric dating and paleontological evidence, however, suggests that most of the phosphatic nodules dredged off California were derived from the underlying phosphatic bedrock of Miocene age (Pasho, 1972). These mainly low-grade phosphatic shales crop out at places on the seafloor, are eroded and broken loose by wave and current action, and the rock fragments then serve as nuclei for intermittent addition of phosphatic coatings (often with ferromanganese oxides and other materials). Many nodules are apparently the result of direct erosion and reworking of Miocene phosphatic and nodular shales, but other conglomeratic nodules from Coronado, Tanner, Fortymile and Thirtymile Banks may be mostly Miocene phosphatic clasts cemented within a younger matrix of phosphatic and other materials (Pasho, 1972; Barnes, 1970). During Miocene time the Borderland was characterized by very intense upwelling, by which deep, cold waters rich in dissolved phosphate and other nutrient salts are brought in large volumes to shallow water depths

and the sea surface. Consequently phosphatic material was widely deposited in the Miocene sequences, but it was diluted with much clastic sediment to form low-grade phosphatic shales. The upwelling waters also increased the abundance of organic matter and the reducing environment in the Miocene sedimentary basins, thus favoring the deposition of great volumes of organic-rich sediments. At places on the sea floor the phosphatic bedrock may have greater areal distribution and thickness than the phosphorite nodules and pellets. However, the phosphatic bedrock seems to have no economic potential at present, even if deposits of sufficient grade could be found, because of mining costs.

b. Manganese Nodules

Manganese nodules on the seafloor have been known for more than one hundred years. During this time reported occurrences have been predominantly from the abyssal (deep) ocean floor and submarine ridges, and occasionally on lower parts of continental slopes.

On the shallower continental margins, such as the California Continental Borderland, manganese dioxide occurs sparsely as nodules and commonly as micronodules or grains and coatings on rocks. The nodules from the shallower nearshore localities contain more iron and less manganese than those from abyssal depths (Manheim, 1965). Cronan (1972) studied three samples from an average depth of 1,146 m (3,760 ft) on the Borderland. These few samples suggest that iron forms 80 to 85 percent of offshore California nodules and manganese 15 to 20 percent.

c. Sand and Gravel

Because the Pacific shelf has a relatively youthful shoreline, there has been less erosion and sorting by current-winnowing

of sand and gravel than along more stable shores. Because of these topographic irregularities, sand and gravel deposits offshore California occur as pockets or "bolsons" in small embayments and depressions in the shelf floor. For this reason, deposits are more difficult to locate and exploit. The proportion of gravel to sand is much higher than on the Atlantic shelf, but total exploitable reserves are probably considerably less. Although commercial exploitation has not yet been carried out, areas near the Los Angeles and San Diego urban centers have been indicated for exploration and at least one request to lease has been made (McKelvey et al., 1968).

Requests to lease OCS areas for sand and gravel have been made and are still viable.

d. Carbonaceous Mud

Marine black shales, particularly those deposited in the upwelling environment, commonly contain 5-20 gallons of oil equivalent to a ton (Duncan and Swanson, 1965). Some of them also contain minor amounts of several metals--particularly vanadium, chromium, and zinc in the vicinity of 1 percent, nickel and molybdenum in the range of 0.1-0.3 percent, and uranium in the range of 0.005-0.01 percent--along with several percent of sulfur. Oil has been recovered by destructive distillation from some of these shales in the past; vanadium, uranium and sulfur have been produced from such a shale in Sweden, and serious consideration has been given to recovery of various metals from such deposits in the United States in recent years.

Muds that are the progenitors of such black shales are known in some of the basins off the coast of Southern California (Emery, 1960) and are

probably forming elsewhere. Their composition has not been studied in detail, but it is reasonable to assume that in places they contain comparable amounts of the materials that have some prospective future value on land. But because the land deposits are large and are of submarginal or at best marginal value now, no prospective value at present can be assigned to the shelf accumulations, even though their magnitude is probably large (McKelvey et al., 1968). Santa Barbara basin alone has been calculated by Emery to contain upward of 3×10^{12} tons of these sediments.

e. Glaucinite

Deposits of glauconite (hydrous iron potassium alumino-silicates) sediments are widespread in the Pacific borderland, particularly in areas of slow accumulation at depths of 600-1800 feet, and are in some places associated with phosphorite McKelvey et al., (1968) classify these resources as "possibly present in very large amounts, but of no prospective value." Glaucinite has limited use and is very abundant on land.

f. Barite

Deposits of barite have been identified in the Borderland off the south end of San Clemente Island. It is found from Mero (1964) that "although no work has ever been done to assess the extent or concentration of these deposits, from the information available, it appears unlikely that extensive deposits of these barium-sulphate concentrations will be found on the ocean floor. Such deposits that do exist, however, may be economically mineable." Emery (1960) suggests the origin of barite found near San Clemente Island was authigenic,

forming from a baritic solution rising along a fault plume from magma at an unknown depth and precipitating on contact with sulfate-containing interstitial water within the sediment covering the fault trace. More work is needed to quantitatively and qualitatively delineate this mineral resource within the Borderland.

B. The Climate of Coastal Southern California and Adjacent Waters

1. General Climatology and Seasonal Weather Patterns

The Southern California coastal and offshore area has a Mediterranean Dry Summer Subtropical Climate characterized by warm, dry summers and mild, wet winters. This is a result of Southern California's location on the southeastern edge of the Pacific High Pressure Area (Pacific Subtropical Anticyclone). The high forces most of the lows that develop to follow a course northward of the United States, bringing about a stable weather pattern that would not otherwise exist (U.S. Coast Pilot #7, 1968).

a. Summer

During the summer the dominant climatic control is the Pacific High. This anticyclonic (high pressure) cell strengthens and migrates northward during late spring, and reaches its maximum development during the summer with its eastern edge off the coast of Oregon and California, where active subsidence occurs. This results in air heating by compression; therefore, a temperature inversion is created at about the 2,000 ft. level. The relatively cold water that is flowing southward along this coast not only maintains equable summer temperatures but creates a surface inversion by chilling the overlying air. These two inversions result in an extremely stable atmospheric condition, and precipitation is generally precluded during the summer.

April, May and June are the cloudiest months, with low-lying stratus which is often associated with unmeasurable light drizzles. This thick, gray overcast, usually less than 3,000 ft.

thick, may last for several days or even a week or more. As summer approaches, clouds recede during the day as solar heating becomes dominant, and only night and morning coastal cloudiness remains. During summer, a thermally-induced low pressure center is created in southwestern Arizona. This, coupled with the strengthening of the Pacific High results in a pronounced sea breeze condition during the day along the coast, superimposed on the general northwesterly circulation.

Although from June through August, and often into September, the weather map changes only slightly from day to day, occasional non-periodic weather does occur. The most frequent is the warm Santa Ana condition, with its hot, dry northeast winds. Usually this pattern does not produce strong winds below the canyons and on the coastal fringe; however, on occasion, extremely strong gusts have been noted. The Chubasco rain is somewhat less frequent in coastal Southern California than the Santa Ana. The origin of this condition is in the tropical waters west of southern Mexico and Central America. Moist, maritime tropical air masses could invade this coastal zone from either the Pacific or the Gulf of California, and bring hot, humid weather associated with thunderstorms. On extremely rare occasions tropical storms, too, have been observed over Southern California waters. The least frequent pattern results when the Atlantic Subtropical Anticyclone strengthens and migrates to the west. A moist tongue then may enter Southern California and bring warm and humid weather with thunderstorms (Kimura, 1974).

b. Winter

As winter approaches the Pacific Subtropical Anticyclone weakens and migrates to the south. However, the high pressure cell continues to be the dominant controlling force for coastal Southern California weather. Winter is the rainy season with 95% of the precipitation being received between November through April. However, there are many more non-rainy than rainy days. The weakening and the southward migration of the Pacific Anticyclone permit the large storms that form over the sea (Aleutian Low) to invade Southern California as early as in October. Usually, the storms are short in duration, lasting only for a day or less. On occasion, however, storms of longer duration occur, lasting as long as a week. The predominant circulation is still northwesterly. During winter and spring, the winds can reach velocities of about 40 knots with resulting 10 foot waves. Superimposed on these winds are those associated with the passage of storms and fronts. The circulation is usually southeasterly in advance of a cold front. Although this wind can attain a force exceeding 50 knots, the southeasterly is the least frequent of the severe winds. After the passage of the cold front, continental air may build up over the Basin and Range Plateau, and thus produce a cold Santa Ana condition. During such periods extreme wind conditions may be experienced below the canyons and over the channel (gale to hurricane force winds) which could result in high seas. Despite heating by compression, temperatures remain low, because of the low initial temperature, but freeze conditions are rare. The relative humidity can decrease

to 5% (Kimura, 1974).

2. Sky Cover and Visibility

The dominant cloud type over the Southern California Coastal and offshore area is stratus occurring with greater frequency during the early summer thru late summer months (April to October) than the winter months (November to March). At times stratus may persist for a week or more at a time. Ceiling heights vary from the surface to 8,000 feet with the greatest frequency between 1,000 and 5,000 feet. Tables B-1 and B-2 in Section II-B. of Appendix 10 give January and July percentage frequencies of low cloud heights for Southern California within 1/2 degree quadrangles.

Visibility is predominantly restricted by fog. However, smoke, rain, smog and dust created by Santa Anas can also reduce visibility.

The U. S. Coast Pilot #7 (1968) states that both summer and winter type fogs are common along the Pacific coast, with the summer type being more frequent and extensive. The generally light anticyclonic winds which prevail during the warm months, when the North Pacific High remains stable, are conducive to both the formation and maintenance of fog.

On the lower coast of California from Los Angeles southward, the foggiest months are those from September to February, and the least foggy, from May to August. Table II-2 lists the monthly frequency of visibility of 2 miles or less in the Southern California Bight Region. The visibilities are normally less in the eastern portion than in the western portion. For example, the

Monthly percentage frequency of visibilities of 2 miles or less, summarized by $\frac{1}{2}$ degree quadrangles. Data taken from Climatological Study, Southern California Operating Area, U. S. Navy, 1971. (Hyphen means fewer than 5 observations of visibility).

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visibilities during June, July and August are less than 2 miles 2 to 12% of the time in the western portion (34.0° to 34.5° N, 120.0° to 120.5° W) and 20 to 24% in the eastern portion (34.0° to 34.5° N, 119.0° to 119.05° W).

Although Southern California is considered to have a minimum frequency of fog occurrence below Point Arguello, the fog at Point Arguello is invariably thick and is recognized by mariners as one of the most dangerous on the coast. Also, there are two very foggy spots off the coast of Los Angeles. These are San Miguel Island and Buffalo Springs on Catalina Island (U. S. Coast Pilot #7, 1968).

3. Surface Wind Patterns

The prevailing winds along the California coast south of 40° north latitude are generally from the northwest flowing nearly parallel with the coast averaging between 5 and 10 knots (9-13 miles/hr.). As the coastline trends toward an east-west direction, the winds shift to a west-southwest direction (U.S. Coast Pilot #7, 1968). Fig. II-8 shows the average annual wind speed (knots) and direction for the Southern California off-shore area. The northwesterly winds result from the semi-permanent Pacific High Pressure Area off the coast.

Northwest winds are the strongest and most dominant during the summer when the high reaches its greatest development. As the winter months approach, the high pressure cell weakens and moves southward. The winds are still primarily from the northwest, but they are somewhat reduced in frequency. The

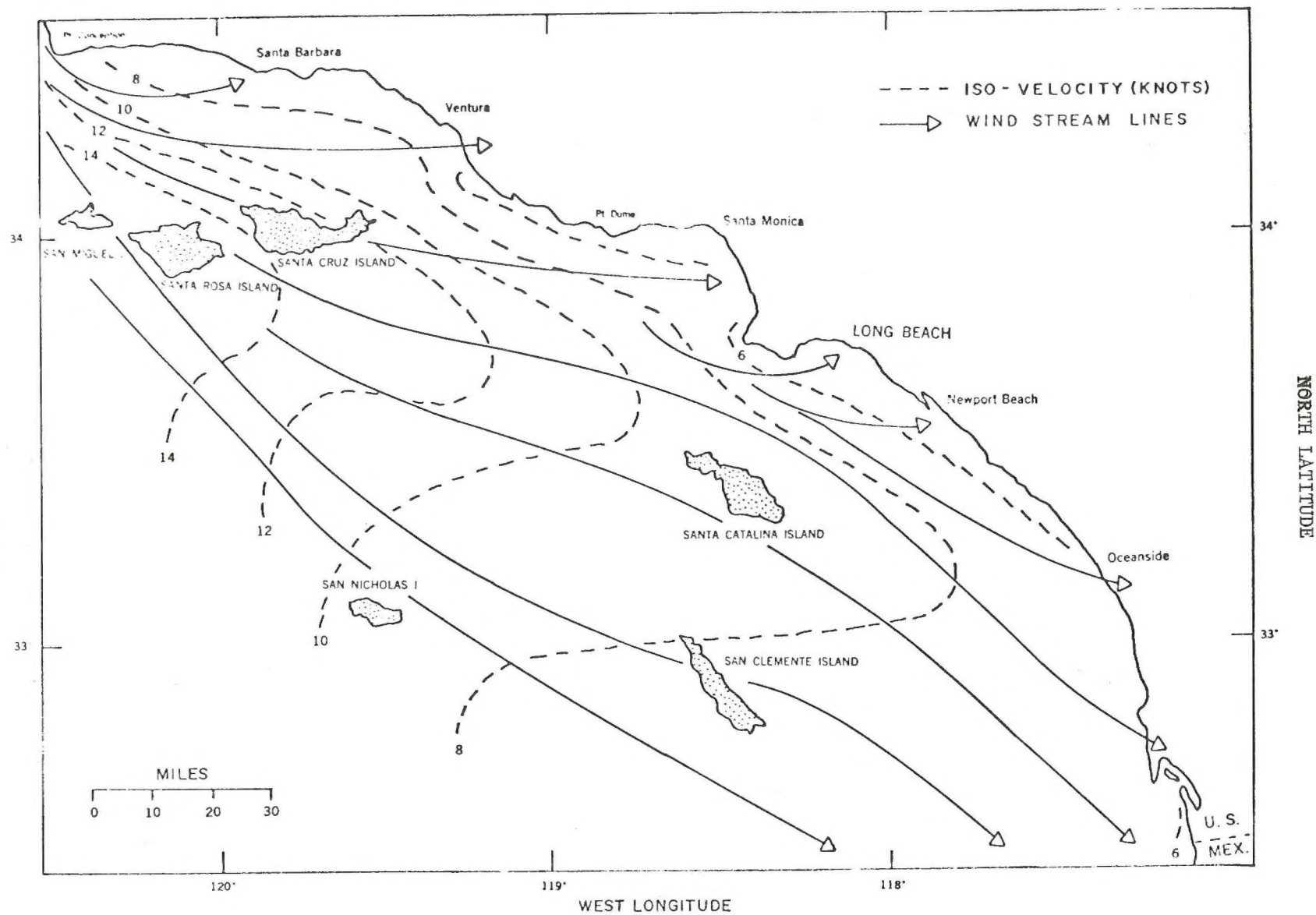


Figure II-8 Annual average wind. From: Allan Hancock Foundation (1965).

weakening of the high and its southward movement allows low pressure cells which may develop to move through the area modifying the wind speed and direction. When a storm approaches from the west, winds are from the east and southeast, and at times these winds are strong and damaging. As the storm moves inland, winds veer to the south and southwest; and as the front passes, northwest and finally northeasterly winds may result. The diurnal sea-land breezes also have modifying effects on the general circulation patterns (Kimura, 1974).

During the summer months the sea breeze is persistent and strong while the land breeze is relatively weak. The sea breeze starts around 7 or 8 A.M. and may continue until 10 P.M.. Fig. II-9 shows the mean surface winds in California for July. During the winter months the sea breeze weakens and lasts only from 11 A.M. until 5 or 6 P.M.. The rest of the day is dominated by the land breeze flowing seaward (U.S. Coast Pilot #7, 1968). January surface winds are portrayed in Fig. II-10 illustrating the modifying effects of the land breeze along the coast. Wind roses for each one-half degree grid square illustrating average directional frequencies and mean speeds (knots) for July and January are presented in Fig. II-11 & II-12.

4. Surface Air Temperatures

The prevailing westerlies with the modifying influence of the ocean, bring moderate and equable temperatures to the coast of California. The normal summer and winter range averages between 59 - 77° F. (15 - 25°C). Temperatures above 90° F. (32.2°C.) occur occasionally during the summer months, but below freezing



Figure II-9 . Predominant Mean Circulation of the Surface Winds in California during July. Shading represents mountainous and intermediate areas. From: Battelle Pacific Northwest Laboratories (1973).

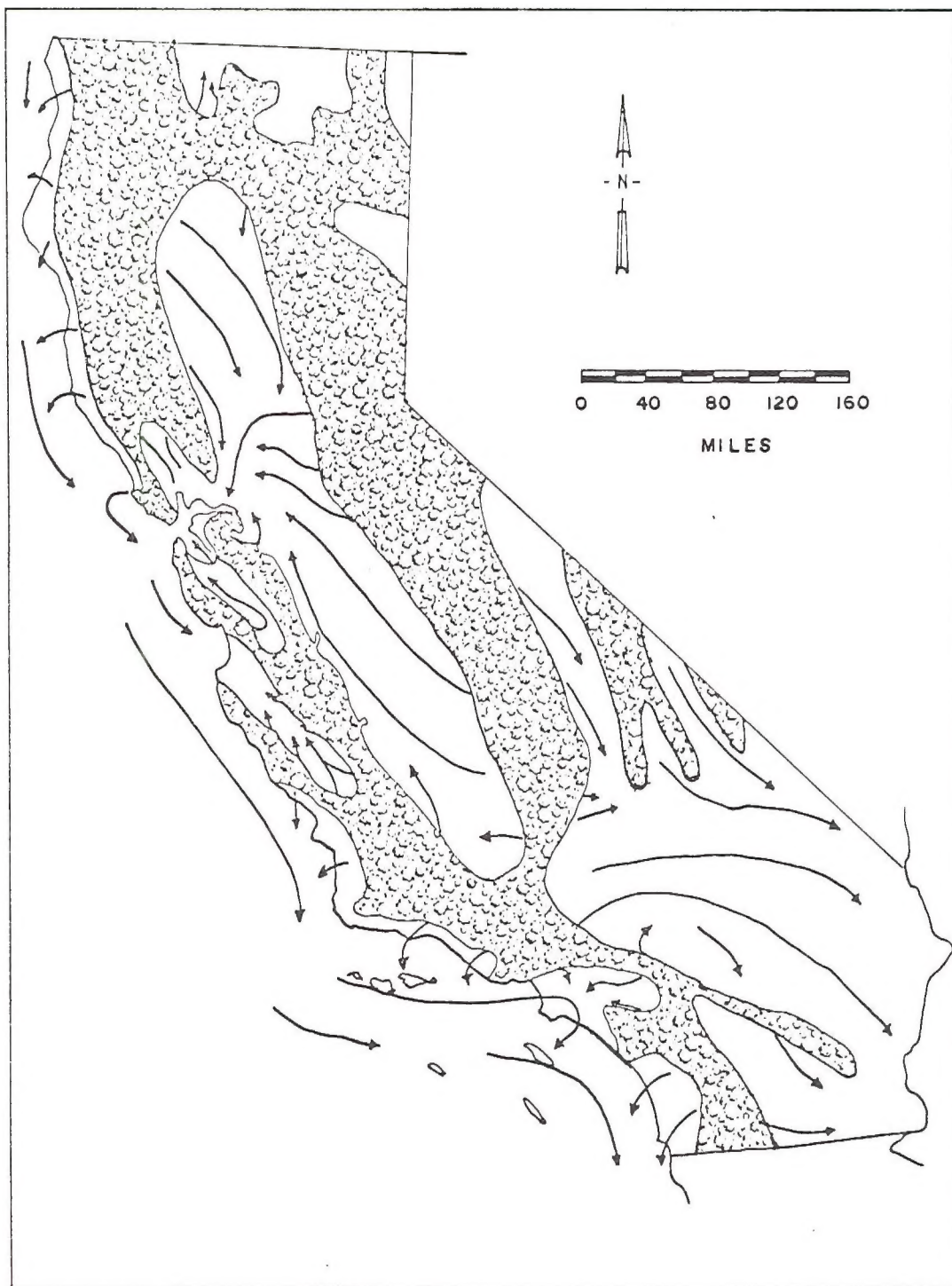


Figure II-10 Predominant Mean Circulation of the Surface Winds in California during January. Shading represents mountainous and intermediate areas. From: Battelle Pacific Northwest Laboratories (1973).

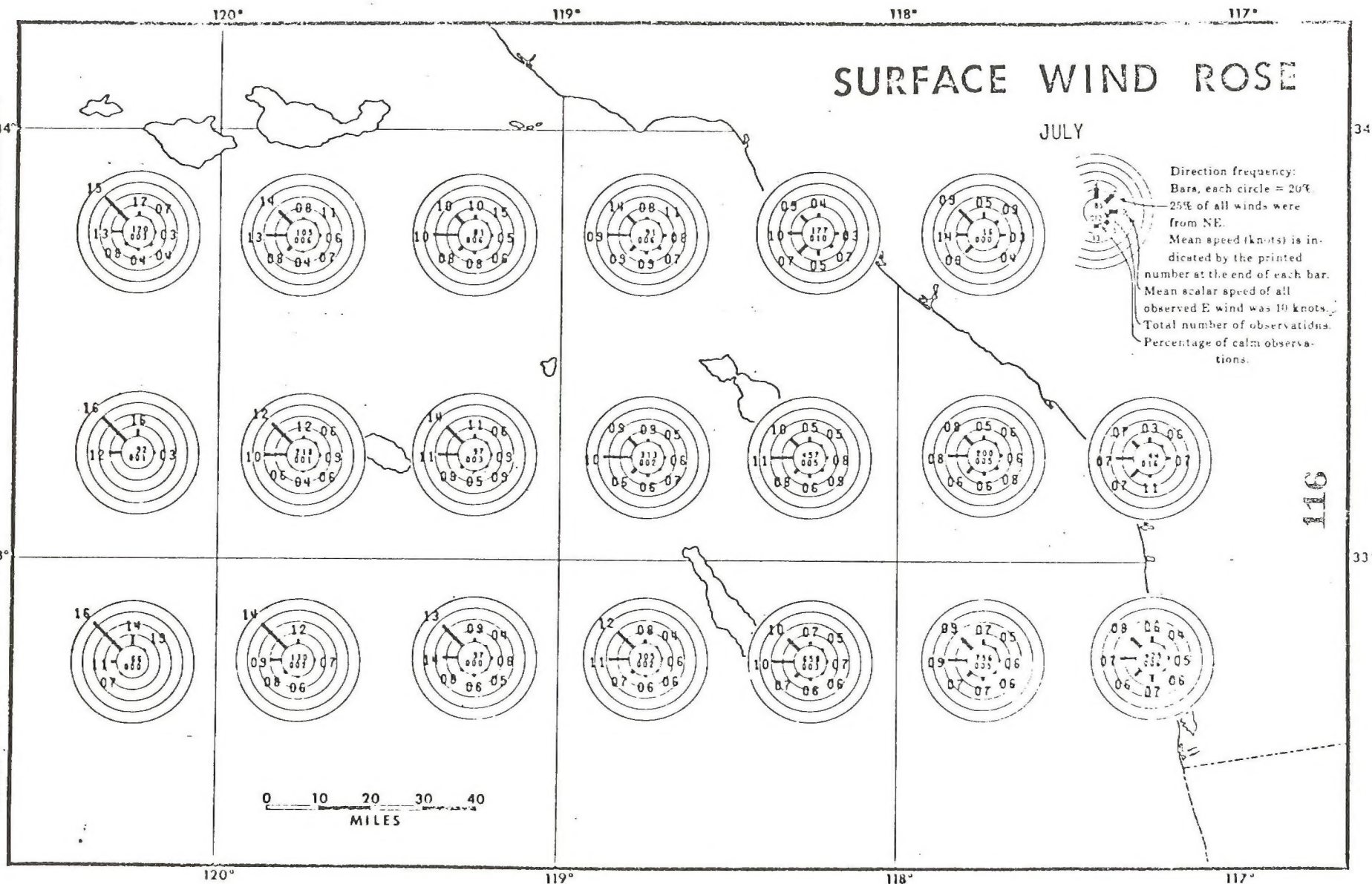


Figure II-11. From: Climatological Study Southern California Operating Area.

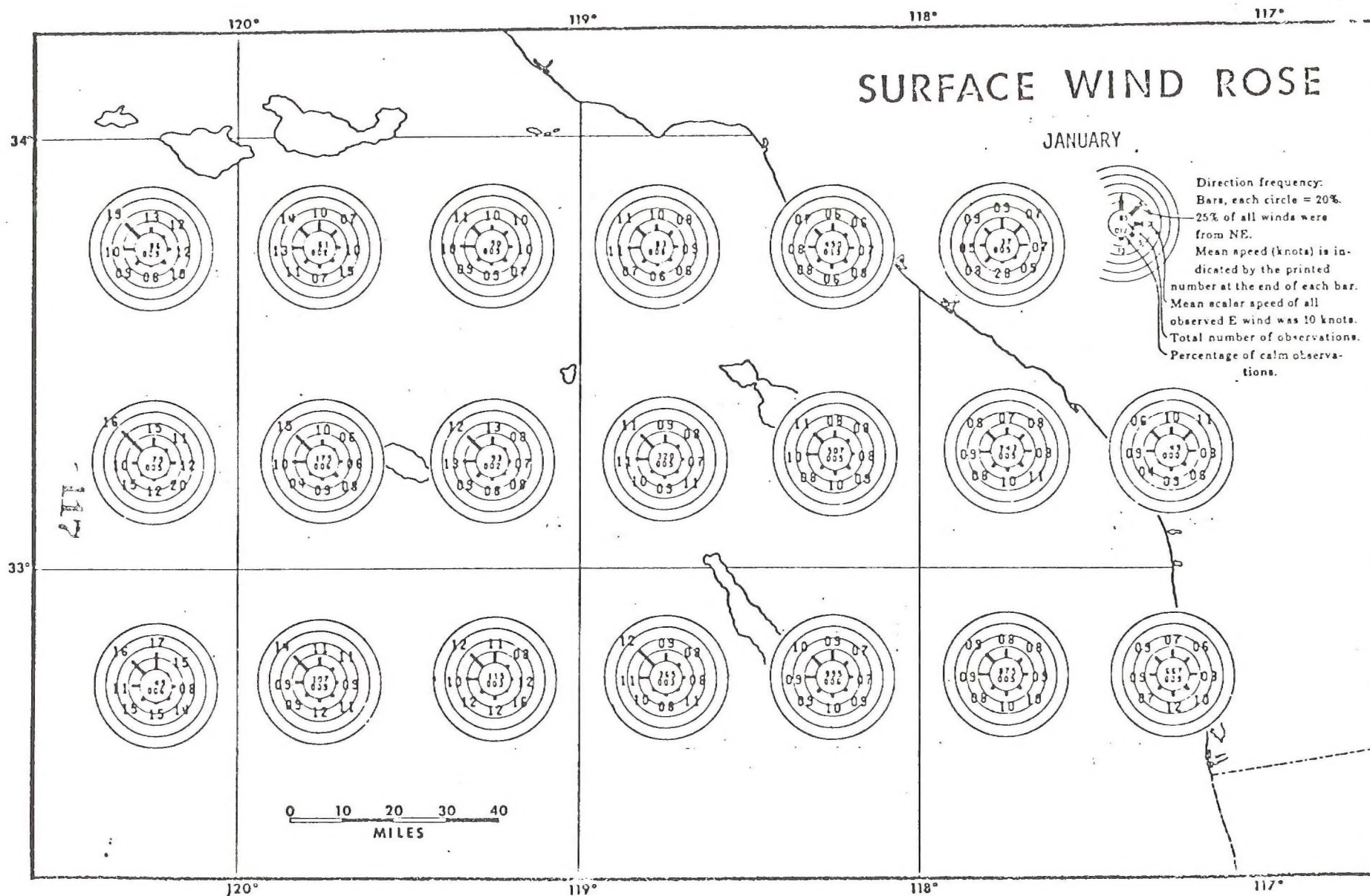


Figure II-12 . From: Climatological Study Southern California Operating Area.

temperatures are uncommon below San Francisco (U.S. Coast Guard Pilot #7, 1968).

Temperatures reported at different land stations vary with the location and elevation. Coastal stations report annual average temperatures of 59°F. (15° C.) for Port Hueneme and 62°F. (16.7°C.) for San Diego. Riverside, which is further inland reports 63°F. (17.2°C.) and Squirrel Inn, a San Bernardino Mountain station, reports 50°F. (10.0°C.) as an annual average (California Department of Water Resources, 1964).

a. Winter

Mean January air temperatures shown in Fig. II-13 are approximately 2 to 5° F. (1.1-2.8° C.) lower along the coastal land areas than those over the adjacent water. Fig. II-13 also shows temperatures along the coast and over the water tend to increase southward. Temperatures over the water increase slightly for about 20 miles seaward in the southern portion of the map and then remain fairly constant.

b. Summer

Mean August temperatures for Coastal Southern California and adjacent waters shown in Fig. II-14 are similar to January means in that temperatures increase southward. However, that is the only similarity. Unlike the January temperatures which increase seaward for a few miles and then remain constant, the August temperatures onshore and nearshore are similar and show a constant decrease seaward.

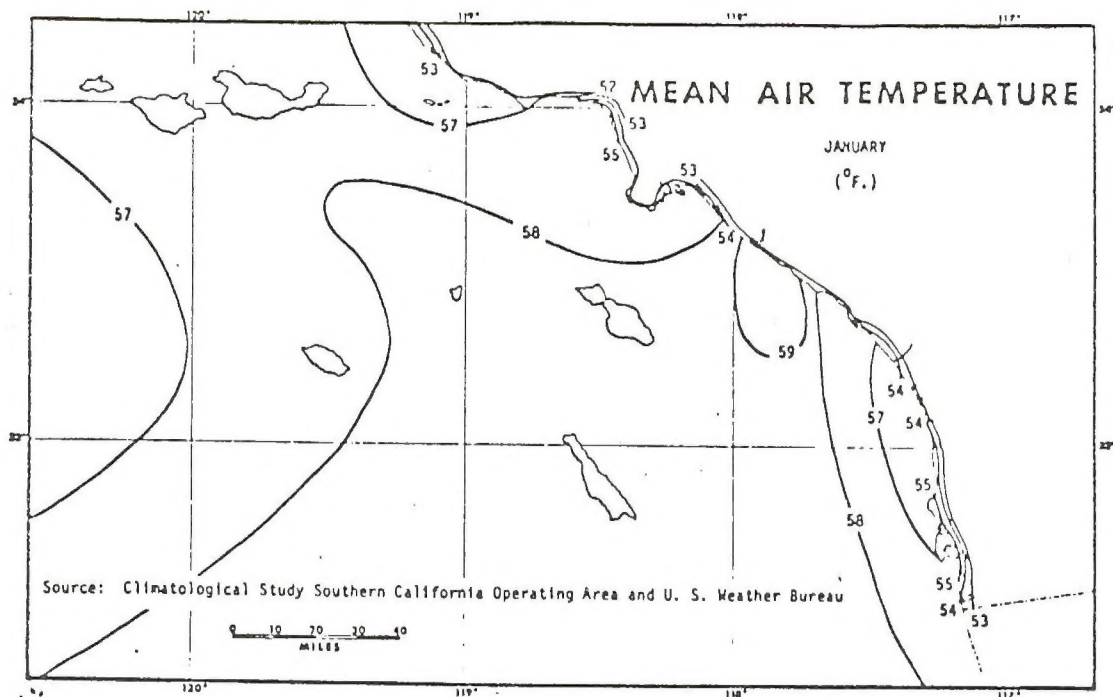


Figure II-13

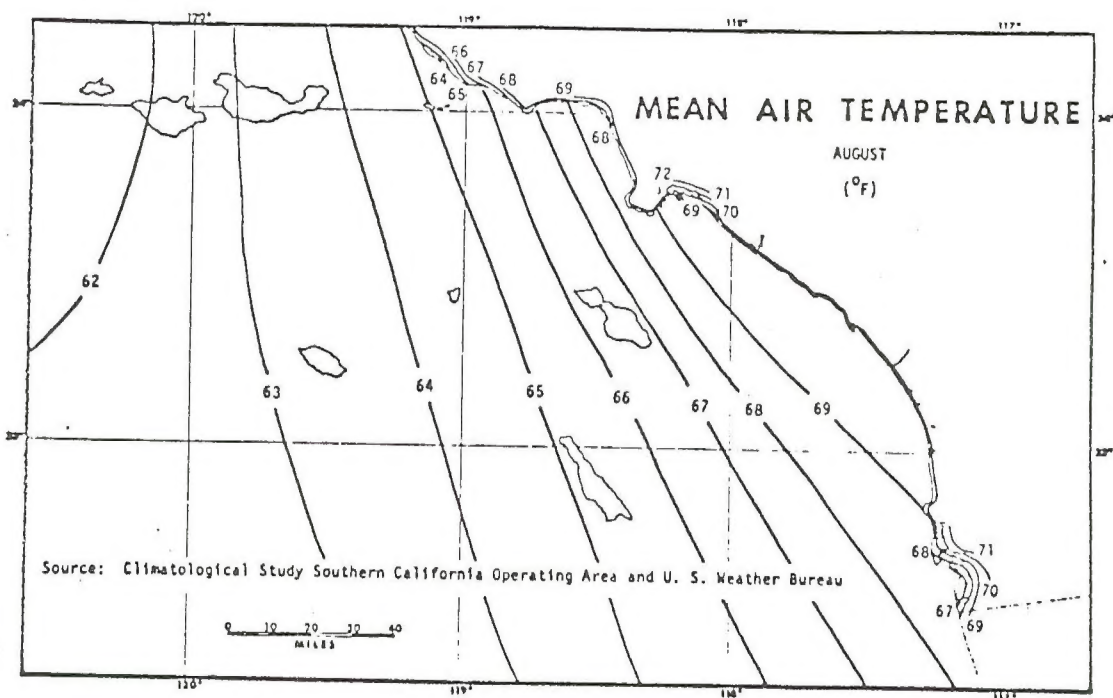


FIGURE II-14

5. Precipitation

In Southern California, annual precipitation varies with distance from the coast, elevation and topography. Precipitation in the coastal lowland areas occurs mainly in the form of rain while in the mountain areas it occurs both as snow and rainfall. Most of the precipitation in Southern California falls mainly during the winter months, with the summer months being generally quite dry. Serious flooding can occur during the winter months with heavy rains and rapid runoff from the mountains and coastal slopes. Annual precipitation in the lowlands along the Pacific coast decreases from north to south. For example, Santa Barbara has approximately 17 inches (43 cm.) of precipitation annually, Los Angeles has 13 inches (33 cm.) and San Diego reports only 10 inches (25 cm.). Table II-3 shows 1968-69 annual precipitation for 22 selected reporting stations in Southern California. The wetter locations in the interior lowlands are usually on the seaward side of the mountains and at elevations above 300 m. Precipitation increases as the valley floor rises to the mountains. In such areas as Big Bear Lake, Cuyamaca and Mt. Wilson annual precipitation may reach as high as 30 to 37 inches (76 to 94 cm) (SCCWRP¹, 1973).

Because of the scarcity of reporting stations on the offshore islands, extreme difficulty is encountered in determining the average annual values. However, Avalon Pleasure Pier reports 13 inches (33 cm.) and Santa Catalina Weather Bureau Airport shows approximately 14 inches (36 cm.). San Nicolas Island has 7.50 inches (19 cm.) and the northern portion of San Clements has an average

1. Southern California Coastal Water Research Project.

TABLE II-3
Annual Precipitation At Selected Stations
In The Southern California Coastal Basin

Ref. No.	Station	Annual Precipitation (cm)-(in.)					
		Normal		1968		1969	
		(cm)	(inches)				
1	Santa Barbara	43.4	(17.0)	29.7	(11.6)	74.9	(29.4)
2	Ojai	51.6	(20.3)	30.7	(12.0)	116.1	(45.7)
3	Oxnard	37.3	(14.6)	25.4	(9.99)	53.3	(20.9)
4	Sandberg Weather Serv. Off.	30.7	(12.0)	11.9	(4.68)	42.9	(16.8)
5	Los Angeles Weather Serv. Off.	32.8	(12.9)	18.8	(7.40)	40.1	(15.7)
6	San Fernando	43.7	(17.2)	18.3	(7.20)	70.6	(27.7)
7	Pasadena	51.3	(20.1)	19.8	(7.79)	82.3	(32.4)
8	Mt. Wilson	78.0	(30.7)	30.7	(12.0)	166.9	(65.7)
9	Long Beach Weather Serv. Off.	25.1	(9.88)	14.5	(5.70)	51.1	(20.1)
10	Pomona (Calif. State Polytechnic College)	47.5	(18.7)	23.9	(9.40)	73.9	(29.0)
11	Corona	31.2	(12.2)	17.5	(6.88)	62.2	(24.4)
12	San Bernardion Co.	45.0	(17.7)	19.6	(7.71)	81.3	(32.0)
13	Big Bear Lake	81.5	(32.0)	31.5	(12.4)	141.7	(55.7)
14	Beaumont Pumping	52.1	(20.5)	28.7	(11.2)	83.3	(32.7)
15	San Jacinto	32.8	(12.9)	16.5	(6.49)	43.4	(17.0)
16	Elsinore	25.4	(9.99)	14.5	(5.70)	55.9	(27.0)
17	Laguna Beach	32.0	(12.5)	14.7	(5.78)	56.6	(22.2)
18	Warner Springs	40.1	(15.7)	24.1	(9.48)	60.5	(23.8)
19	Escondido	41.1	(16.6)	15.5	(6.10)	47.2	(18.5)
20	Cuyamaca	96.3	(37.9)	41.7	(16.4)	118.1	(46.4)
21	San Diego Weather	27.2	(10.7)	9.4	(3.70)	29.7	(11.6)
22	Barrett Dam	43.9	(17.2)	21.1	(8.30)	57.4	(22.5)
	Average of 22 Stations	45.0	(17.7)	21.8	(8.58)	73.2	(28.8)

1968 was a relatively dry year for the entire coastal basin--as little as 40 percent of the normal annual precipitation was recorded. Conversely, 1969 was a relatively wet year, with up to 220 percent of normal annual average precipitation. From: SCCWRP (1973)

annual precipitation of 5.40 inches (13.7 cm). It is estimated that the summit (1965 ft. or 599 m) of San Clemente Island has an average annual value of about 7 inches (17.8 cm.). Strange (unpublished 1973) estimates the annual rainfall of San Miguel to be about 11.5 inches (29.2 cm.), Anacapa Island slightly less than 10 inches (25 cm.) and Santa Barbara Island about 6 inches (15.2 cm.).

Kimura (1974) states that average annual precipitation and totals for individual years indicate that precipitation figures are lower on the offshore islands. Based on this information, isohyets for the offshore waters were estimated and portrayed as dashed lines on Figure II- 15. Because the average annual values decrease from the coast to the offshore islands, it can be assumed that this trend also prevails over the sea. Accordingly, the isohyets over the ocean were drawn to show both a southward and seaward decrease of precipitation starting from the coast (Kimura, 1974).

6. Severe Storms

a. Thunderstorms

The coastal areas of the Pacific states normally have the smallest number of thunderstorms per year in the entire United States. Thunderstorms occur most frequently during the late summer and early fall months and during the middle and late winter months, but they can occur at any time of the year (Rosenthal, 1972).

b. Funnel Clouds

Only one or two tornadoes (funnel clouds reaching the ground) are reported in California a year. Tornadoes occurring

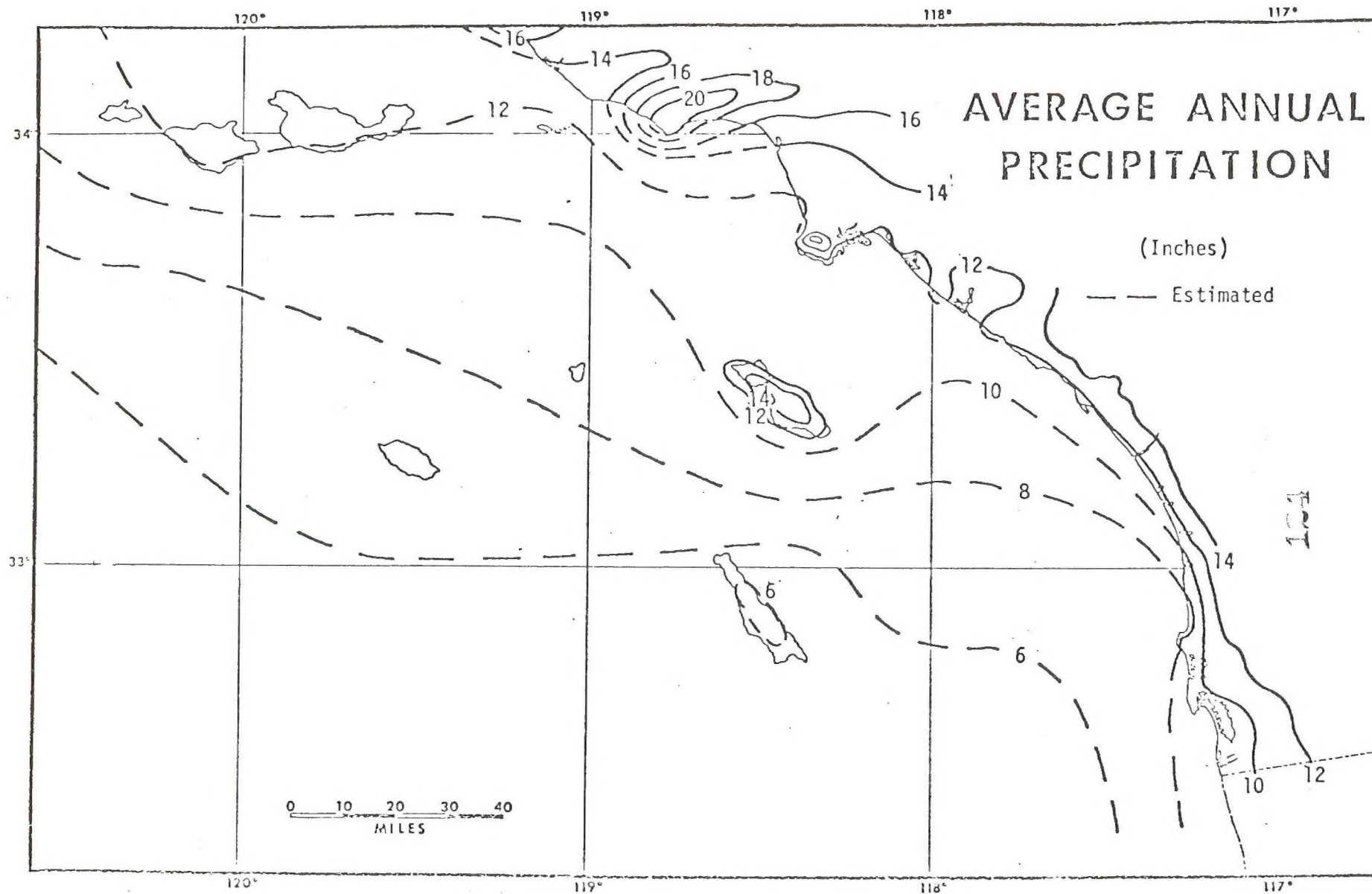


Figure II-15. From: Department of Commerce, Weather Bureau, and United States Navy.
(Kimura, 1974)

in California are smaller and weaker than those that occur in the Midwest and, as a consequence, do little more than damage trees and light buildings (Aldrich, 1972; Elford, 1970 cited by U.S.G.S., 1974)

c. Tropical Cyclones

Tropical cyclones usually develop during the summer and fall in or near the Gulf of Tehuantepec and move northwest. Many of the cyclones dissipate long before they reach the Southern California coast. However, they do cause some swell in the area at times, but it is usually low in height.

Only one hurricane in well over 50 years (Sept. 25, 1939) hit Southern California with high winds and extensive damage (U.S. Coast Pilot #7, 1968). With a center pressure of 971 mb. and winds of 60 knots, the hurricane dumped 2 to 4 inches (5 to 10 cm.) of rain along the coastal area and inflicted severe damage in the Los Angeles area as a result of heavy wave action.

Although the U.S. Coast Pilot #7 (date 1968) states that only one hurricane has caused severe damage in the last 50 years, it should be pointed out that conditions can occur which may produce several hurricanes over a shorter time period. For example, SCCWRP (1973) points out that weak summer northwesterly winds and a sluggish California Current encourage the development of high water temperatures and the invasion of Southern California by tropical storms, such as the fierce Mexican Chubasco. In some periods in the early 1800's, the Southern California coast apparently was affected by these hurricanes several times a year. These conditions were probably accompanied by abnormally high temperatures in autumn.

7. Severe Winds

a. Northwest Winds

The Northwest winds are the most important severe winds. They occur more often and can occur at any time of the year, however, they are predominantly in the spring. The winds frequently exceed 25 knots with maximum speeds of 60 to 65 knots over the Northern Channel Islands area (Fig. II-16). Strong northwesterly winds are most often associated with a high pressure buildup offshore following the passage of a low inland (Strange, unpublished, 1973).

b. Northeast Winds (Santa Ana)

During the fall and winter months, Santa Ana winds occur from the east and northeast. As a high pressure area builds up over the Basin and Range Plateau Region, the dry desert air moves predominantly through Cajon Pass into the Great Valley of Southern California. If the pressure difference between Nevada and Southern California is only moderate, the winds are usually confined to narrow belts flowing either through the Santa Ana River Canyon toward San Pedro Bay or directly over the low mountains south of the canyon, then along the level plains through Orange County toward the Newport vicinity. Although the stream may shift its position from time to time, the width and velocity tend to remain about the same. These winds may reach speeds of 52 knots, at times carrying considerable dust. They may continue to blow well out to sea. However, beyond 50 miles (92 kilometers) the winds are sufficiently diminished to be of no particular concern. Fig. II-17. Santa Ana winds can

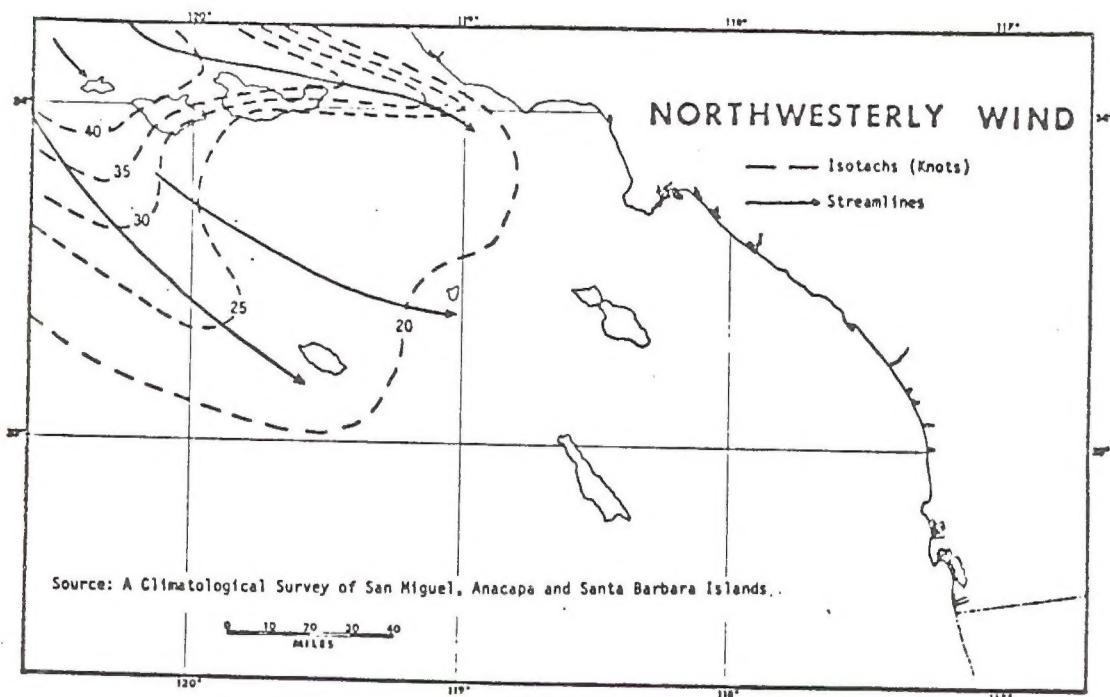


Figure II-16

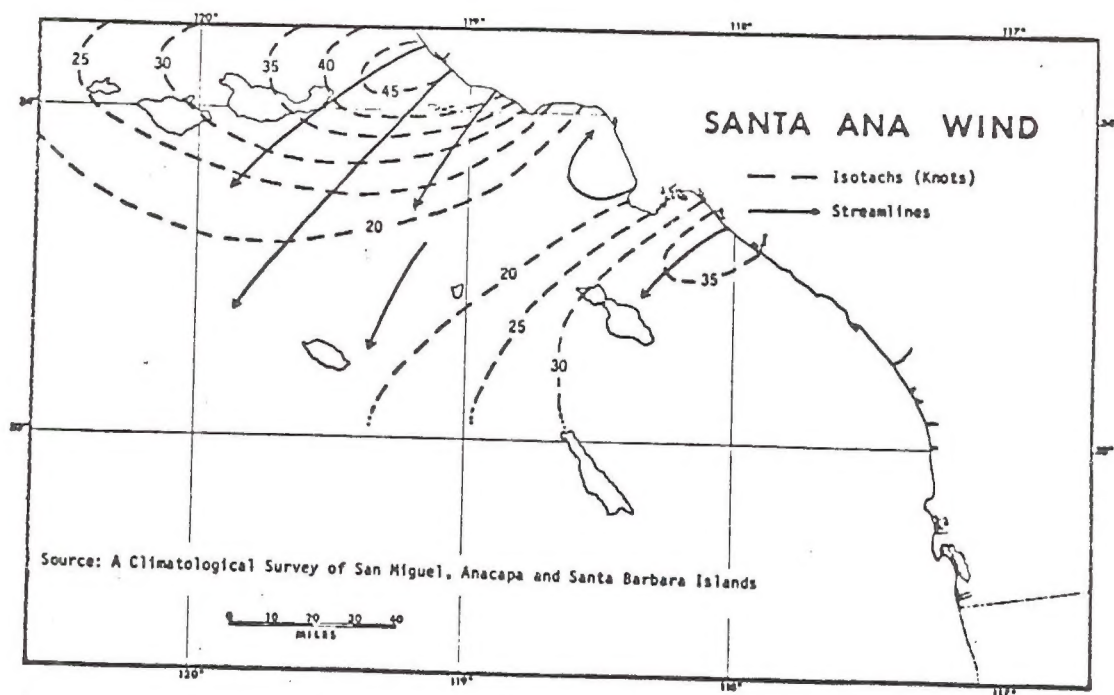


Figure II-17

occur anytime of the day, but are usually the strongest from 7 A.M. to 9 A.M. when the land breeze is most prominent (U.S. Coast Pilot #7, 1968).

c. Southeasterly Winds

The southeasterly winds are the least frequent of the severe winds, but are still potentially damanging. They usually occur in advance of an approaching cold front, with winds generally less than 50 knots; however, winds of 75 to 80 knots with gusts exceeding 100 knots have occurred near Point Conception (Kimura, 1974).

d. Vulnerability of the Offshore Islands to Severe Winds

Strange (unpublished 1973) states that, on the one hand, San Miguel Island, the westernmost of the Channel Islands, is most vulnerable to the northwesterlies (Fig. II-16). On the other hand, Anacapa Island, the closest to the coast, receives lighter northwest winds since the winds diminish as they progress southeastward. However, Anacapa is most vulnerable to the Santa Ana winds (northeasterly) (Fig. II-17). Approximately 18 Santa Ana conditions per year are reported at Anacapa. Finally, most of the islands are vulnerable to southeasterly winds.

8. Humidity

Relative humidity is the actual moisture content of a sample of air expressed as a percentage of that contained in the same volume of saturated air at the same temperature. As the temperature or mixing ratio (mass of water vapor in grams per kilogram of dry air) changes, the relative humidity changes.

The Southern California coast average relative humidities range from about 60% to 90%. Relative humidities in the area are generally highest during the late spring and summer. Under "Santa Ana" conditions in the fall and winter, relative humidities are commonly as low as 20% and at times below 5% in some places. Relative humidities are generally highest at night and lowest in the late afternoon.

9. Inversions

Inversions in Southern California are generally created by subsiding air, from the Pacific High Pressure Area, causing air aloft to be warm and dry through compression heating while cool stable marine air is trapped below. Since the Pacific High is most prevalent during the summer it follows that inversions are stronger during the summer and weaker during the winter when an occasional complete absence occurs (Edinger and Wartele, 1971). Beneath the inversion layer, natural particules and air pollutants are trapped and cannot mix with the air above. This causes a layer of haze normally to exist in the cool marine air (Aldrich, 1966). As the inversion layer lowers, the haze becomes thicker since the air particles have less air to mix with.

There is a distinct difference in the pattern of pollution distribution in summer and in winter. During the summer and early fall the temperature inversion is strong, low and persistent, causing vehicle exhaust to accumulate; sunlight is intense for many hours and the photochemical reaction proceeds rapidly, forming nitrogen dioxide and ozone. During the winter, surface inversions

are frequent during the long nights and early mornings, but tend to lift rapidly or to be destroyed by surface heating. This causes primary contaminants (oxides of nitrogen, hydrocarbons, carbon monoxide) to accumulate during the night and early morning, but to disperse before they can react to produce much nitrogen dioxide or ozone. Because of the lesser intensity and duration of winter sunlight, photochemical activity is reduced; hydrocarbons and oxides of nitrogen do not react rapidly to form ozone and nitrogen dioxide. During the winter, furthermore, greater quantities of oxides of nitrogen (mainly nitric oxide) are emitted because of increased consumption of fuel by stationary sources. Thus, the winter is marked by higher concentrations of primary contaminants and little ozone, and by several hours of high concentrations of nitric oxide during the day, and of nitrogen dioxide at night. The summer pattern is high daytime concentrations of ozone, nitrogen dioxide and aerosols, which disappear during the night, following the termination of photochemical reactions with the setting of the sun (APCD CO. of L. A. 1971). Table II-4 presents a chart giving meteorological factors favorable to photochemical smog formation in Los Angeles and the number of days per year all conditions were favorable.

Atmospheric pollution is discussed in greater detail in Section IV.E.

TABLE II-4

METEOROLOGICAL FACTORS FAVORABLE
TO PHOTOCHEMICAL SMOG FORMATION

Summer 1970 Vs. Highest Two Years Since 1950

Rule 57 Days*	No. of Days With Surface Inversion	No. of Days With Inversion Below 1500'	No. of Days Max. Mixing Height 3500'	Wind Speed		% Sun- shine July Aug. Sept.
				No. Days 5 mph	Avg.	
57 in 1970	17 in 1970	78 in 1970	104 in 1970	96 in 1970	4.7 in '70	91 2/3 in 1970
68 in 1962	20 in 1969	80 in 1960	103 in 1969	112 in 1962	4.7 in '69	93 1/3 in 1969
59 in 1960	30 in 1963	86 in 1952	104 in 1960	97 in 1960	4.8 in '59	85 in '58

* A "Rule 57 Day" is one on which the inversion base at 4:00 a.m. PST is lower than 1500 feet, and the maximum mixing height is not above 3500 feet and the average surface wind speed between 6:00 a.m. and 12:00 noon PST does not exceed 5 miles per hour.

Source: L.A. County-APCD Profile, 1971

C. Physical Oceanography

1. Circulation

a. Surface Circulation

The large scale surface water movements in the Southern California Borderland area are principally the result of winds, the earth's rotation, and solar heating. However, a number of complex, smaller scale motions produced by local conditions are superimposed on this overall pattern.

The current along the California coast is a continuation of the westerly drift in the North Pacific, which intersects the western coast of North America and divides into two components. The southern component of this flow becomes the California Current, while the northward component becomes the Alaska Current. The point of divergence is approximately 45° north.

The California Current, typical of eastern boundary currents, is best described as a meandering, diffuse, southeastward flow, with short-term variations in speed that are of the same order as the mean speed itself (15 cm/sec.). The current originates near the Canadian border and initially contains water characteristic of the subarctic. As this water moves southward, the surface characteristics are modified by solar heating and by the effects of river inflow and exchange with estuaries and embayments. The flow generally follows the coastline southward until it reaches the northern limit of the Borderland area at Point Conception. Here, the coastline turns abruptly towards the east, and the flow of water departs from the coast, generally continuing in a southeastward direction. Further south, off

the coast of northern Baja, California, the main portion of the current turns toward the land, and the flow divides into two branches. One branch, known as the Southern California Countercurrent, turns northward and flows through the Channel Islands, forming the inshore edge of the Southern California Eddy. The second branch turns southward and continues down the coast of Baja, California, where it eventually turns westward and contributes to the North Equatorial Current.

Figure II-18 gives a composite picture of the surface circulation in the region of the Southern California Borderland areas. North of Point Conception, the California Current flows southeastward with a mean speed of approximately 15 cm/sec (0.54 Km/hr) and a volume transport of $12 \times 10^6 \text{ m}^3/\text{sec}$ (Pavlova, 1966). There is no true western edge to this current. More than 90 percent of the south-eastward transport is within 800 Km of the coast of central California and is located above 300 m depth (Sverdrup and Fleming, 1941).

Within 150 km of the coast, north of Point Conception, the surface currents often flow northwestward along the coast from about November through February. This commonly produces an inshore surface countercurrent (the Davidson Current), which remains until the northwesterly winds resume in the spring.

The Southern California Countercurrent is a nearly permanent feature of the flow pattern in this region and has been found to be well developed in winter and weak in the spring (Schwartzlose, 1963). Its location may be influenced by the shape of the coast and the bottom topography, as implied by Sverdrup and Fleming (1941). Estimates of surface speed in the Southern California Countercurrent are

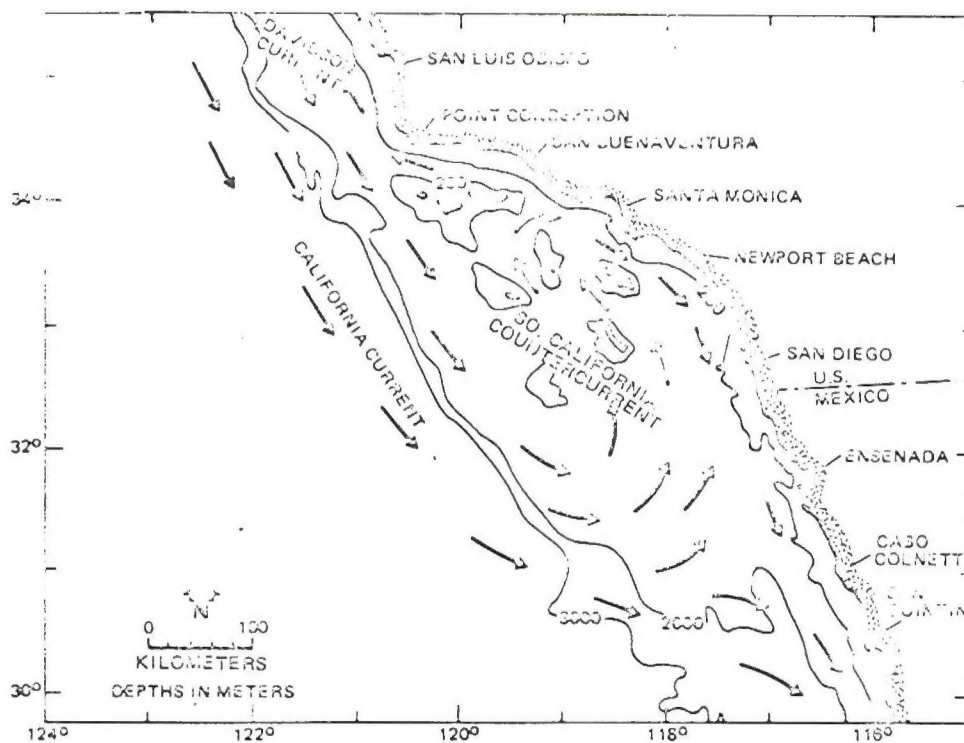


Figure II-18. Generalized Surface Circulation (0-100m) in the Southern California Borderland Area. (Arrows Indicate Approximate Direction of Flow). From: Jones (1971), Fig. 1.

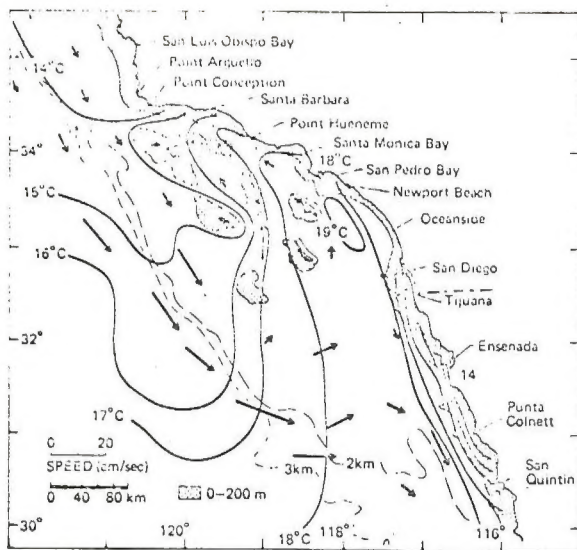
comparable to that observed in the California Current itself: 12 to 18 cm/sec (Sverdrup and Fleming, 1941). Transport estimates in this branch of the eddy are only slightly less than that calculated for the California Current (Pavlova, 1966) and appear to vary seasonally with the California Current (Pavlova, 1966; Sverdrup and Fleming, 1941).

Seasonal variation in the circulation pattern is illustrated by Figure II-19.

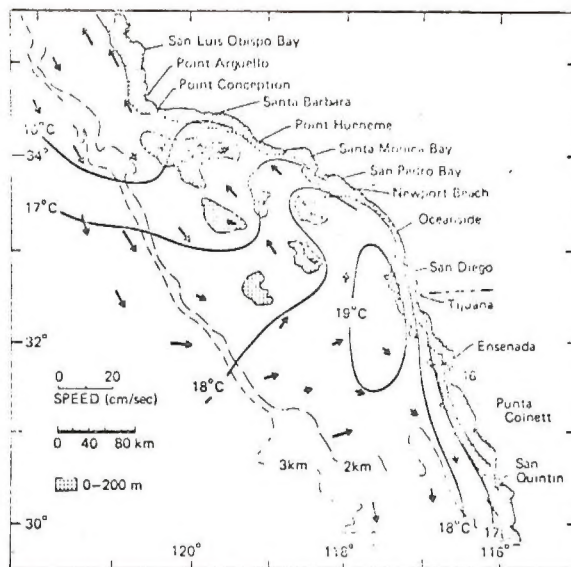
b. Bottom Circulation

Many bottom current measurements have been made in the Borderland area. (Fig. II-20) summarizes maximum near-bottom current data from the various sources. Many of these measurements have been made in canyons or associated fans. While such canyon data are perhaps not entirely representative of currents in much of the deeper offshore basins of the study area, they should tend to indicate an upper bound to the velocities.

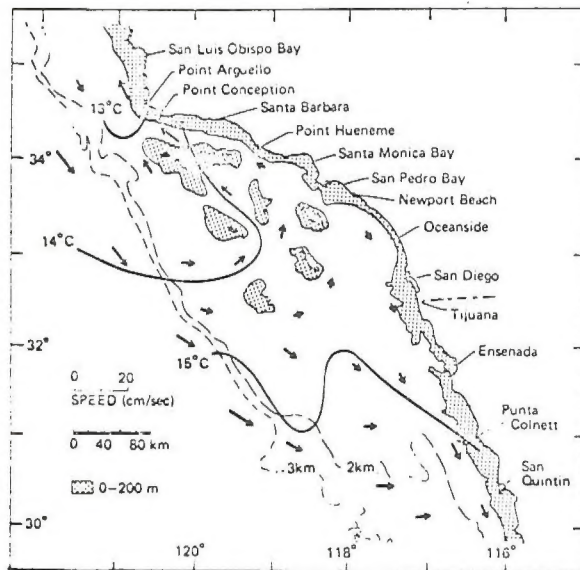
Some of the first deep current measurements were reported by Revelle and Shepard (1939). They found slightly less than 25 cm/sec maximum in the Santa Cruz Basin approximately 0.6 meters above the bottom. Soutar (Intersea Research 1974) reported a maximum of 28 cm/sec three meters above the bottom in the deep portion of Santa Barbara Basin over a period of several days. Edgerton (Intersea Research 1974) has conducted mainly mid-water current measurements (at 150-300 meters but no bottom measurements) in Santa Barbara and Santa Monica Basins and found them significantly different with the implication of stronger currents in Santa Barbara Basin. He considered a bottom current of 25 cm/sec at 600-700 meters to be large with 10 to 15 cm/sec a more typical maximum.



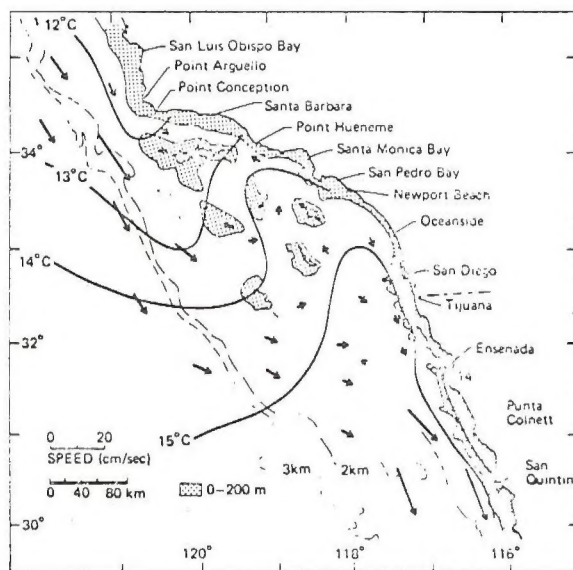
Average geostrophic surface flow (arrows) and surface isotherms (degrees C) in the Southern California Bight during summer (July).



Average geostrophic surface flow (arrows) and surface isotherms (degrees C) in the Southern California Bight during autumn (October).



Average geostrophic surface flow (arrows) and surface isotherms (degrees C) in the Southern California Bight during winter (January).



Average geostrophic surface flow (arrows) and surface isotherms (degrees C) in the Southern California Bight during spring (April).

Figure II-19. Average circulation in the Channel Islands Area for the months of January, April, July and October. From: Jones (1971), Figs. 5-8.

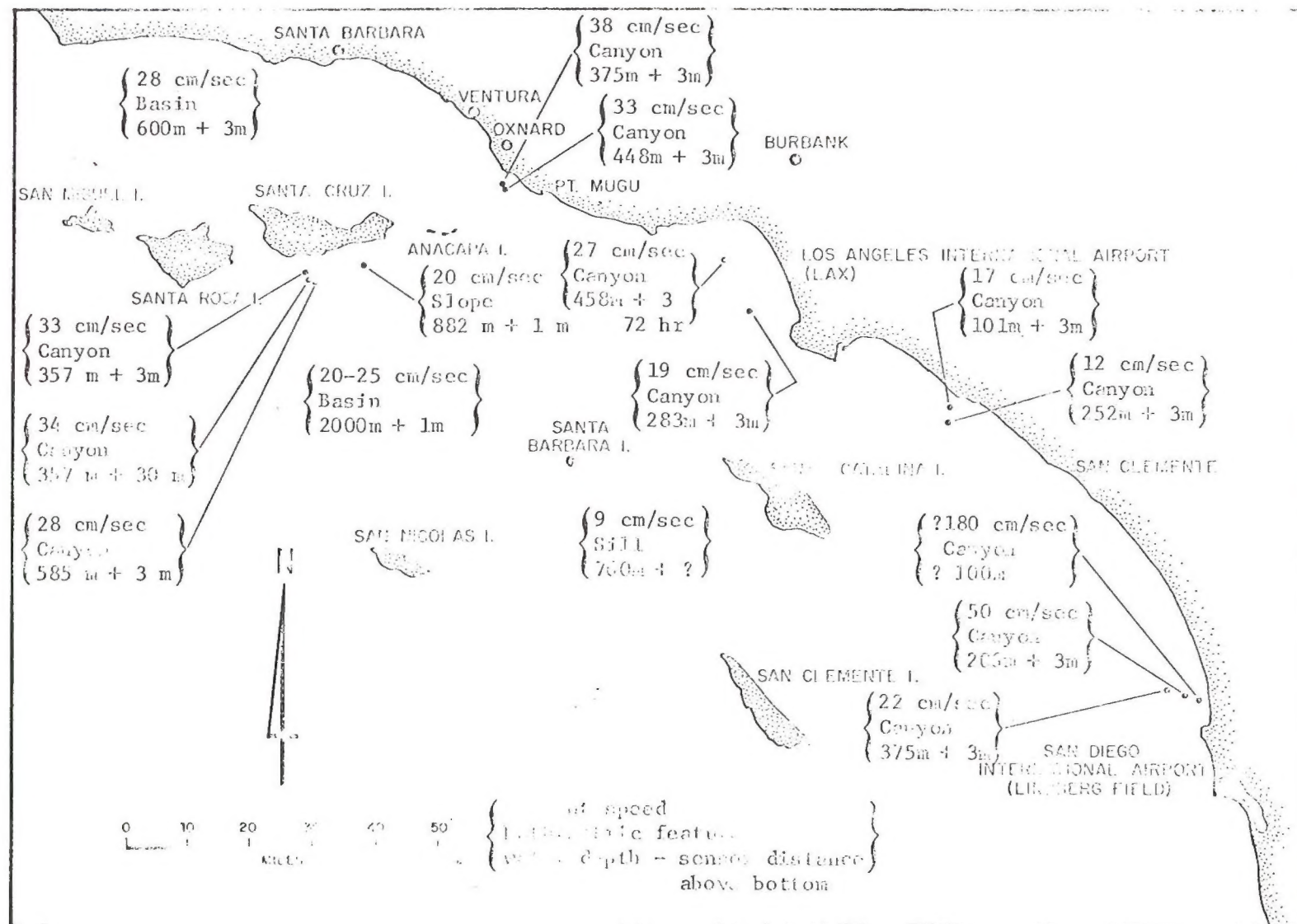


Figure II-20. Observed maximum near-bottom currents. Compiled from various sources.

c. California Undercurrent

A persistent north to northwesterly flowing undercurrent is present at depths of more than 150 to 200 m and less than 500 to 800 m in the Southern California Bight. Wooster and Jones (1970) found a sub-thermocline poleward flow of warm, salty, low oxygen water. The center of the current contains a salinity maximum of $34.4 \text{ }^{\circ}/\text{00}$ to $34.6 \text{ }^{\circ}/\text{00}$, and a sigma-t (i.e., density) level of 26.54. Measurements of salinity and density, which are used to define the distribution of the undercurrent, show that the current is confined by the continental slope in the bight, where it is 20 km wide and 300 m thick. It is broad off Baja, California but narrows to a thin current over the Southern California continental slope, seaward of the 200 m isobath.

Reid (1963) measured maximum current velocities of 8 cm/sec off Southern California. Wooster and Jones (1970) recorded velocities of up to 40 cm/sec, averaging 30 cm/sec, off Baja, California. If these data are correct, then the current diminishes in strength as it moves north into the bight. The volume transport off Baja, California is $2 \times 10^6 \text{ cm}^3/\text{sec}$, about one-fifth of the California Current (Wooster and Jones, 1970). Seasonal variations in the undercurrent are poorly known.

The trough and ridge topography of the Southern California Borderland divides the undercurrent into sinuous streams that flow into the offshore basins. Emery (1960) showed that the basin water characteristics are determined by the sill depths and the undercurrent.

The water mass transported with the undercurrent is formed near South America through gradual transformation of subantarctic water.

Paquette (1972) made 36 days of observations on the slope off Santa Cruz Island one meter off the bottom in 880 meters of water. Implication from his statistical distributions would place the maximum at approximately 20 cm/sec. Shepard et al. (1939) found a maximum of 9 cm/sec at 760 meters on the saddle area between Santa Catalina Basin and San Nicolas Basin.

The remaining measurements reported were within the confines of canyons which may represent topographically enhanced speeds. Typical maximum canyon flows of 25-35 cm/sec were reported (Shepard and Marshall, 1969; Shepard and Marshall, 1973a; and Shepard et al., 1974), with up-canyon speeds similar to down-canyon speeds. In the shallower portions (above 200 meters) of the canyons, the main energy components are not diurnal and semidiurnal tidal, but are higher frequency tidal harmonics or internal wave peaks with periodicities of one to six hours. As the depth of measurements are increased, the semidiurnal, diurnal and inertial energy peaks grow in prominence and dominate below 200-meters depth. Most of these measurements were at three meters above the bottom.

The highest canyon flows measured -- approximately 180 cm/sec measured by Inman's group at Scripps Institution of Oceanography at approximately 100 m in Scripps Canyon (Marshall, Intersea Research 1974) and 50 cm/sec at 200 meters in La Jolla Canyon (Shepard and Marshall, 1973b) -- occurred during major storms and were attributed to turbidity flows. In both cases the current meters were swept from their mounts so the highest reported values do not necessarily represent the maximum speeds of the flows.

It is present at depths of 100 to 800 m, and is much modified by the time it reaches Southern California. Kindyushev (1967) calls it the Equatorial Transformed water mass. This southern water is saltier and denser than the water in the California Current. The undercurrent water mass has a maximum salinity of 34.35 ‰ and temperatures that range from 6° to 11°C. This undercurrent water mass mixes with the California Current water mass at its upper boundary.

d. Nearshore Circulation

The currents measured over the continental shelf seaward of the surf zone appear to be dominated by the local wind, the tides, and the offshore geostrophic current direction.

Daytime current measurements at or near the surface record velocities in the range of 5 to 20 cm/sec, occasionally reaching 36 cm/sec (Allan Hancock Foundation, 1965). Currents commonly vary in direction up to 90° and sometimes as much as 180°. Maximum velocities over the mainland shelf occur anywhere from the surface to near the bottom. Usually the velocities are greatest at the surface, being about twice those 16 m below. Sewage and oil discharges which have a density less than local sea water float and will be influenced by the surface current directions and velocities.

Drift bottle studies show that there is a high percentage of on-shore surface current. Schwartzlose and Reid (1972) found that bottles dropped 5 to 8 km offshore travel quickly to the coast and are recovered close to their release points.

Santa Monica Bay is frequented by a south-flowing current that induces a slow counterclockwise eddy (Stevenson, Tibby and Gorsline,

1956). Velocities of 10 to 20 cm/sec are most common. Drift card surveys in February and July, 1956, resulted in the recovery of 14% to 50% of the cards showing an onshore motion of water occurring both seasons. The surface currents over San Pedro Channel are complicated. There is a boundary shear between the northwest flowing countercurrent and a southerly inshore current. Gorsline and Grant (1972) found the inshore current best developed during the fall and winter when they measured velocities of 20 to 100 cm/sec. The inshore current was much more restricted and compressed toward the shelf during the spring.

Current measurements off the Orange County sewage outfall showed that the predominant movement was to the east-south-east with a secondary direction of motion to the north-northwest (John Carollo Engineers, 1967). The surface current is primarily wind drift and the subsurface current is tidal. Similar results were found at San Onofre (Marine Advisers, 1965a, 1965b), Oceanside and Point Loma (Gaul and Stewart, 1960; SCCWRP, 1973). The current velocities off San Onofre rarely exceeded 1 cm/sec, and the surface currents off Point Loma have speeds of about 2% of the wind speed.

Current measurements over the San Clemente Island shelf show that the primary current directions are southeast and northwest parallel with the bottom contours. Velocities ranged from 0.0 to 25.0 cm/sec.

2. Water Temperatures

Water temperatures in the Southern California Bight at a depth of 10 m range from 13°C. near Point Conception in January to

19°C. near San Diego in July. For a detailed analysis of water temperatures refer to Appendix 10, Section II.C.

3. Tides

Off the west coast of North America, the tides are both diurnal and semi-diurnal, producing a mixed tide in which, generally, two high tides and two low tides occur each day. The primary generating forces causing the tides are the gravitational attractions of the moon and sun on the earth. The actual day-to-day variation is a result of these forces, as well as the general topography of the ocean shelf.

The tidal heights along the Southern California coast range from about 30 cm to more than 2 m. The time between successive high (or low) tides varies from about 10 to 14 hours.

Off the coast of Southern California, the tide wave moves from the southeast to northwest, following the coastline at such a rate and incident angle that high tide reaches Point Conception about 1/2 hour after passing San Diego. Although the wave speed is nearly 400 km/hour, the associated motion of fluid particles (the tidal current) is a very small fraction of the wave speed (of the order of 20 cm/sec).

4. Wind Waves and Swell

Southern California waves are predominantly from the northwest (prevailing winds) and swell may occur from any seaward direction. Most of the Bight is at least partially protected by the offshore islands. The restricted fetches allow only the development of low waves with short lengths and periods. Larger waves (to 8 feet) are

formed during frontal crossing, but again with short lengths and periods due to limited fetches. It is only when gale winds blow from the west at 35 knots, or more, that high waves are formed in the local region and travel over the shelf. These are most common in the San Pedro Channel, where waves as high as 25 feet have been encountered. Data taken from the Naval Weather Service Command for annual wave heights in the vicinity of 31-34N, from the coast to 120W, indicates that waves of 8 feet or greater occurred in 3% of the observations. However, it should be noted that these data are based upon observations made by ships in passage. Such ships tend to avoid bad weather when possible, thus biasing the data toward good weather samples. For a detailed discussion of synoptic weather conditions which generate significant swell/wave conditions in the Bight and a discussion of internal waves, refer to Appendix 10, Section II.C.

D. Chemical Oceanography

1. Nutrients

Nutrients can be defined as the substances that are needed for marine life to reproduce and grow. In the marine ecosystem phytoplankton constitute the primary producers and as such are dependent on an adequate supply of three essential nutrients: nitrogen, phosphorous, and silica.

The primary sources of supply of these nutrients are upwelling of deep waters, advection, and discharge from land sources (rivers and industrial and domestic sewerage). The primary process depleting the concentration of nutrients in the surface waters is rapid uptake by phytoplankton and consequent removal of the phytoplankton by predation or by sinking. As a result, only low concentrations of nutrients are normally found in surface waters except in local source areas.

The common inorganic nitrogenous nutrients are nitrate, nitrite, and ammonia. In natural sea water, nitrate is the dominant form appearing either as nitrate or reduced to ammonia or in the reverse process, as ammonia is normally present only in small concentrations in natural waters, although in nitrogen deficient waters it may be the dominant form of the nitrogenous nutrients.

The Hancock Foundation surveys found nitrate concentrations in surface waters ranging from 0.01 to 0.16 mg/l in the Bight area. Surface concentrations in the spring months were somewhat higher than those found during the fall and winter months. Nitrate concentrations were significantly higher at 90 m depth, where the mean values ranged from approximately 0.2 to 0.4 mg/l.

In addition to nitrogen, phosphorous and dissolved silica are considered to be the primary macronutrients required for organic production. Silica is utilized almost exclusively by diatoms. In the open ocean, it has been commonly observed that total nitrogen and total phosphorous are found in a relatively constant ratio of about 15 atoms of nitrogen to 1 atom of phosphorous. This relationship is not nearly so constant in nearshore waters, which are affected by generally higher rates of organic production and subject to influences from land-based nutrient sources.

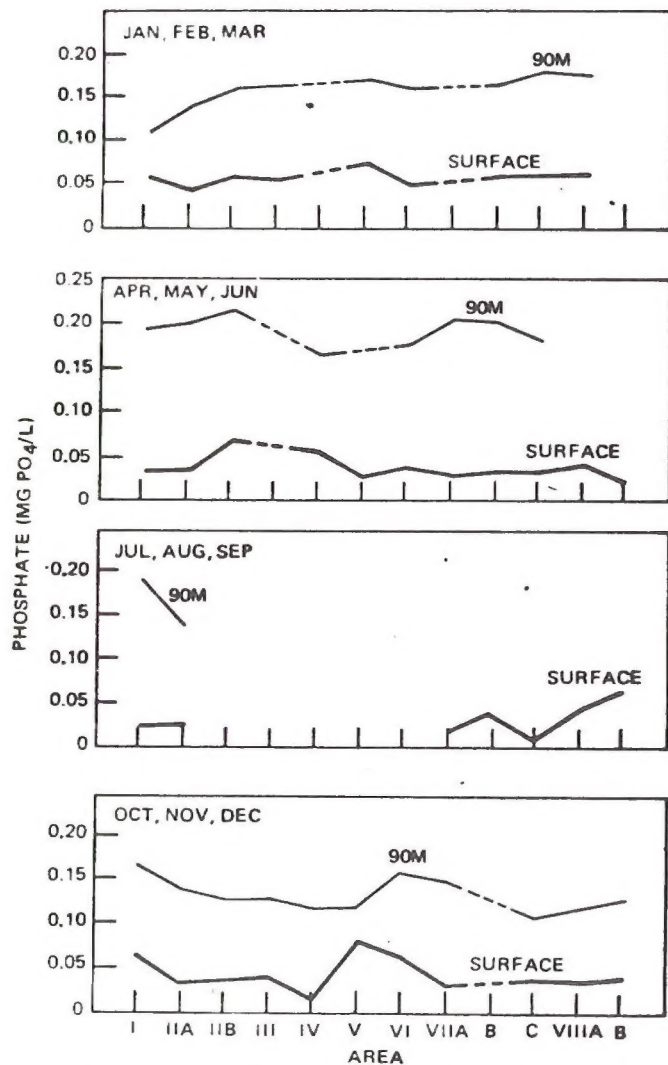


Figure II-21. Distribution of Mean Phosphate by Seasons. From: Allan Hancock Foundation (1965a)

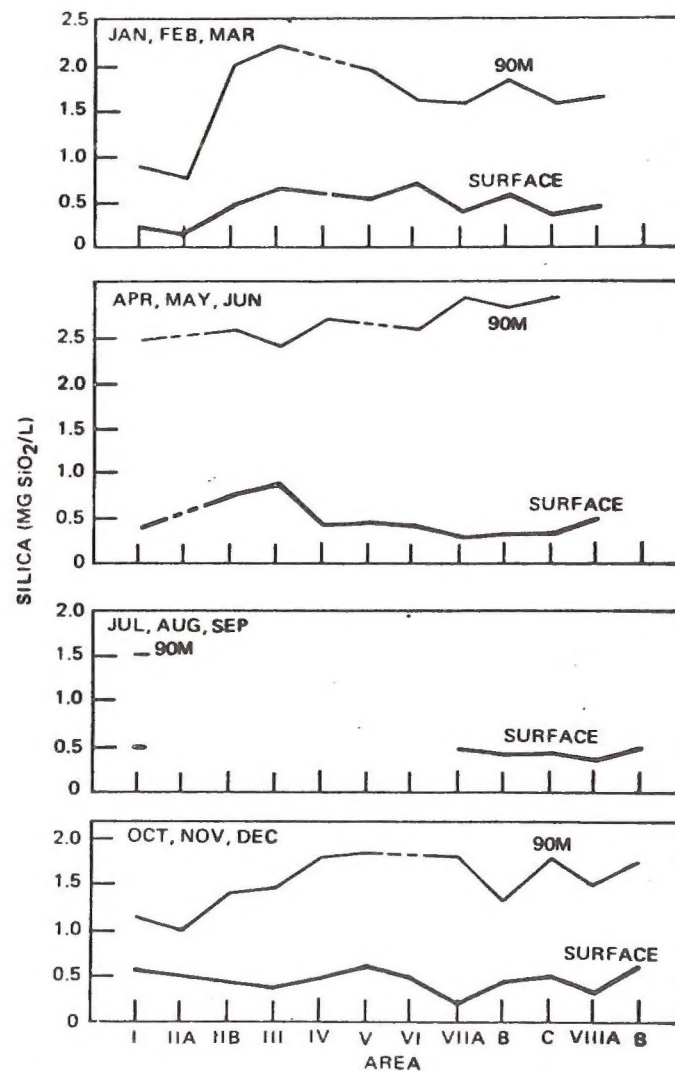


Figure II-22 Distribution of Mean Silica by Seasons. From: Allan Hancock Foundation (1965a)

Mean phosphate and silica concentrations are shown in Figures II-21 and II-22. There is a fairly consistent pattern of increasing phosphate and silica concentration with depth. The difference in concentrations between surface waters and waters at 90 m of depth appear to be greatest during the spring months for both constituents. (SCCWRP, 1973)

2. Salinity

The following is a summary of salinity data as discussed primarily by Maloney and Chan (1974) of the Southern California Ocean Studies Consortium.

The water in the Southern California Bight region of the California offshore is a mixture of relatively low temperature-low salinity water transported south in the California Current with higher temperature-higher salinity water brought north in California Undercurrent. The California Current is found at depths of 40 to 600 m with salinities of 23.5 ‰. Salinities of this concentration are characteristic of a near surface water mass. The northerly flowing California Undercurrent is present at depths of more than 150 to 200 m and less than 500 to 800 m in the Bight Region. It has a higher salinity than the California Current with a maximum of 34.35 ‰. The water in the Southern California Countercurrent is a mixture of Northern California Current water and southern water. At 10 m, the salinities range from 33.4 ‰ to 34.6 ‰ and are 0.1 ‰ to 0.2 ‰ greater than the California Current.

The salinity is a measure of concentration of dissolved salts in water. Basically, the concentration of salinity within the ocean is relatively constant, except around coastal areas where fresh water river discharge may dilute the marine waters for miles offshore. Upwelling, a phenomenon where deeper ocean waters are brought to the surface in

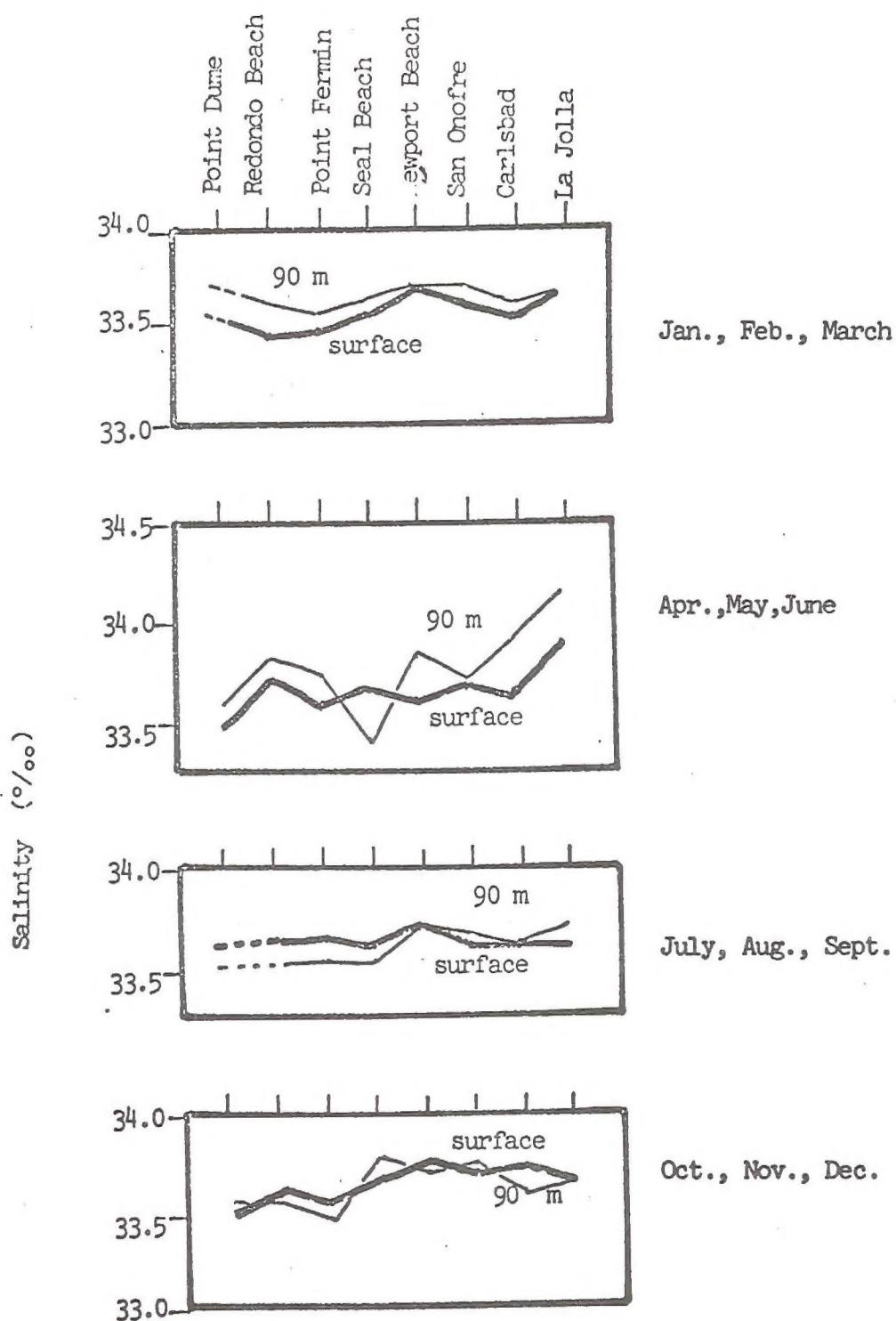


Figure II-23. Latitudinal distribution of mean salinity by seasons. From: Allan Hancock Foundation (1965)

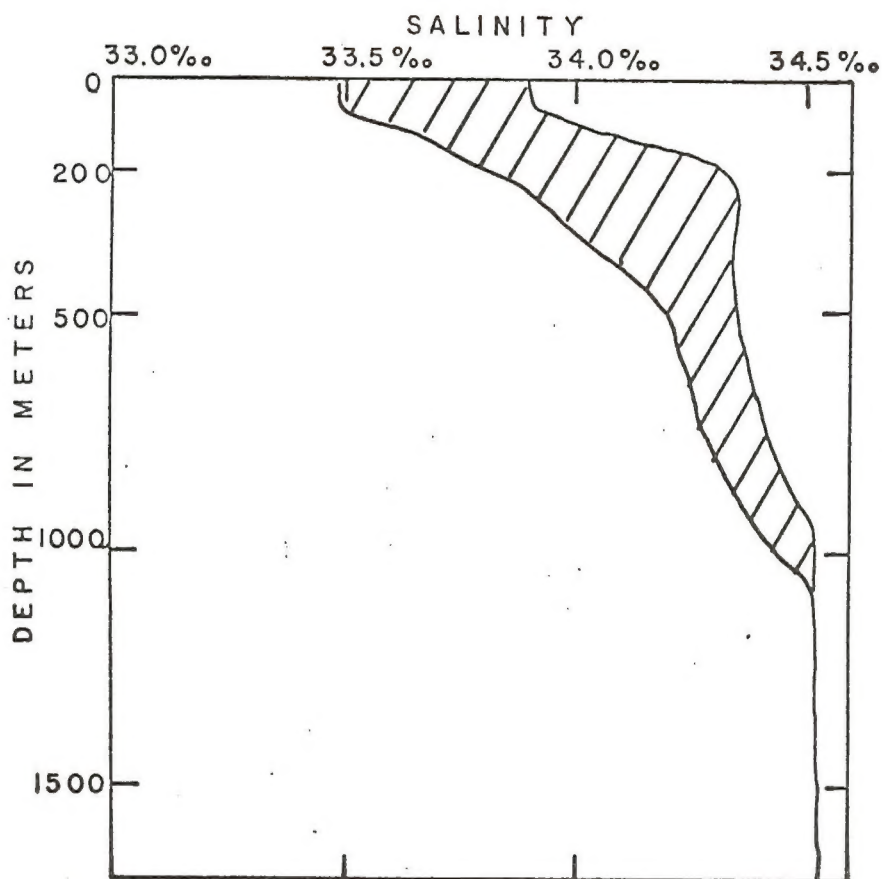


Figure II-24. Salinity - depth diagram for the Southern California Bight. From: Maloney and Chan (1974).

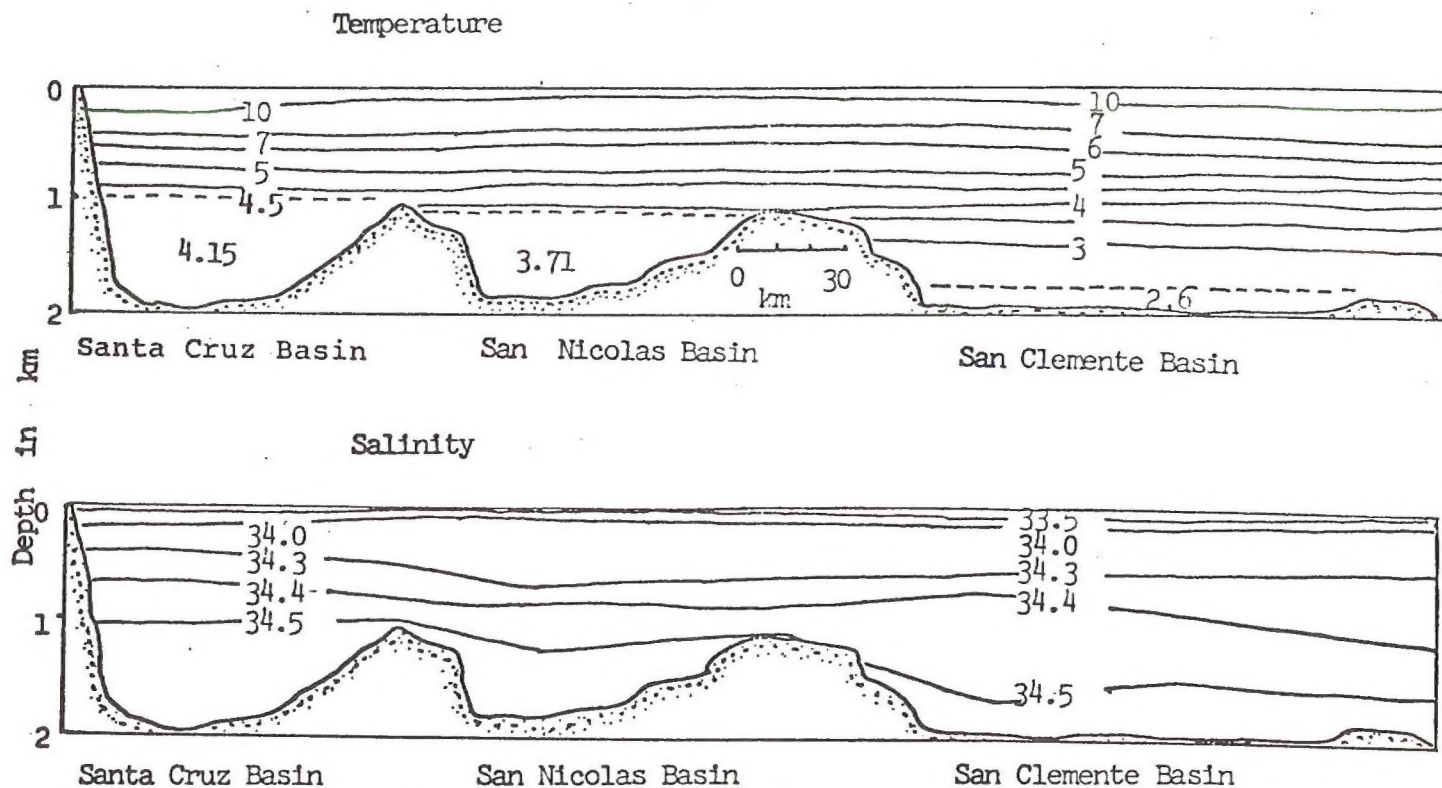


Figure II-25. Longitudinal section through San Clemente, San Nicolas, and Santa Cruz Basins. Isotherms in $^{\circ}\text{C}$ and isohalines in ‰ . Horizontal dashed lines indicate effective sill depths. Water at extreme right is assumed to be like that of Valero Basin. From: Chan (1974)

coastal areas to replace surface waters which are pulled offshore by winds, may also change the salinities of this area.

Variations in the salinity of the water in the Southern California Bight are small, ranging from 33.5 ‰ to 34.5 ‰. The vertical distribution of salinities is shown in Figure II-24. The difference of the salinities with depth and at specific depths is due to the mixing of water masses from different depths and areas which have different salinities due to their physical constituents and fresh water flux throughout the year. From Figure II-25 a profile of the salinity gradient across the basins of the borderland shows that the highest gradient is found in the shallower water with gradient relatively constant at deeper depth.

The surface water is more saline during the summer and autumn than in the winter and spring (Allan Hancock Foundation, 1965). This results from the greater amount of rain during the winter and increased evaporation during the summer (SCCWRP, 1973). See Figure II-23 for the seasonal variation of salinity for the water above 100 m. The annual range of surface salinity is 0.5 to 0.8 ‰ with the mean salinity ranging between 33.3 to 33.6 ‰ (Kindyushev, 1970).

The salinities in the mixed zone, 200 to 500 m deep, are intermediate between the northern water which increases in salinity from 33.85 ‰ at 200 m to 34.22 ‰ at 500 m, and the southern water which is almost isohaline at 34.3 ‰ to 34.4 ‰. The maximum halocline is developed under the California Current. The deep water below 1,000 m has salinity values of 34.5 ‰ to 34.6 ‰; the water column is almost isohaline (Allan Hancock Foundation, 1965).

3. Dissolved Oxygen

Oxygen is a product of plant photosynthesis, and in turn is used by plants and animals in their metabolic processes. In addition to photosynthesis by marine flora, the distribution of dissolved oxygen is influenced by free exchange with the overlying atmosphere and turbulent mixing of the upper ocean layers by winds, tides, and currents.

The California State Water Resources Control Board (1965) "Water Quality Criteria" (p. 115) quotes a dissolved oxygen value of not less than 5 mg/l as one of the criteria for the quality of water used for the propagation of fish. (Although derived for fresh water, the implication is that the criterion applies to marine waters.) It notes that, along with the other criteria guides, the value is "favorable" and not merely sublethal. This is not to say, however, that fish are not found or cannot survive in waters with a concentration of dissolved oxygen less than 5 mg/l.

This level of dissolved oxygen should not necessarily be construed as the minimum level for the survival of benthic invertebrates. Many species can withstand greatly reduced oxygen levels (See Section II.E.3b.).

The oxygen characteristics described above apply only to the mainland shelf waters. In deeper waters and, particularly, in several of the basins adjacent to the shelf, oxygen values are extremely low. Decomposable organic material is present in such high amounts in the waters and sediments of these nearshore basins that dissolved oxygen values below the still depths are in the order of 0.3 to 0.4 mg/l and may fall as low as 0.1 mg/l. Table II-5 shows all basins of the Southern California continental borderland have extremely low DO, but the inner basins

are nearer to being anoxic than the outer basins; i.e. Santa Catalina, Santa Cruz, San Nicolas, Tanner, West Cortes, and San Clemente.

From 500 to 700 m the dissolved oxygen concentration decreases to a minimum of about 0.7 mg/l. It increases with depth below 700 meters and reaches 3 mg/l at 2,000 meters. The oxygen minimum layer is consistently found below the thermocline layer wherever it is present. Off the west coast of the United States the oxygen minimum layer originates between 28°N and the Equator, and it extends westward like a wedge (Sverdrup, et al., 1942).

The water in the marine basins has approximately the same oxygen content as the water outside the basins at the same depth as the basin sills. The shallower basins have sills at the depth of the oxygen minimum layer and so their oxygen concentrations are only about 0.7 mg/l, while deeper basins have dissolved oxygen of 2 mg/l, (Chan, 1964).

Table II-5 (SCCWRP, 1973)
PHYSICAL AND BIOLOGICAL DATA FROM THE BASINS OFF SOUTHERN CALIFORNIA

Basin	Depths		Bottom Temp (°C)	Bottom Dissolved Oxygen (mg/l)
	Sill (m)	Bottom (m)		
Santa Barbara	475	627	6.3	0-0.3**
Santa Monica	737	938	5.0	0-0.3**
San Pedro	737	912	5.1	0.2
Santa Cruz	1,085	1,966	4.2	0.8
San Nicolas	1,106	1,833	3.7	0.5
Santa Catalina	974	1,357	4.0	0.4
San Clemente	1,815	2,107	2.6	1.3
East Cortes	1,415	1,979	3.1	0.9
Tanner	1,165	1,551	3.8	0.6
West Cortes	1,362	1,769	3.4	0.8
Velero	1,902	2,571	2.5	2.0
Long	1,697	1,938	2.7	1.4

Bottom dissolved oxygen and temperature from Emery 1960.

**Water in the extreme bottoms is anoxic.

4. Trace Metals

Although trace materials such as metals are difficult to measure and are therefore less well known, many are as essential to biological productivity as are the better known nutrients such as phosphate, nitrate, and silica. Examples of physiologically essential metals are copper, cobalt, zinc, iron, manganese, boron, molybdenum, and selenium. Yet these same trace elements, which are essential to a healthy physiological state, are toxic in certain concentrations to some organisms and may also be concentrated and/or transformed to a state toxic to organisms high in the food web. As trace metals are present in waste discharges, it is essential to learn the effects, if any, that they have in local and regional marine waters.

It is difficult to ascertain general concentration levels for trace metals in sea water. The difficulty arises from two sources. First, the sea water concentrations of these constituents are usually near the limit of detection by analytical techniques and contamination of samples during collection and analysis is common. Second, there is usually uncertainty as to the physical/chemical state of the constituent, and analysis is difficult.

The variability resulting from these factors is superimposed on the natural variability of concentrations in the waters. Total concentrations and the state of trace materials in coastal waters can be expected to vary significantly from those in offshore waters. Similarly, concentrations in surface waters and in deep ocean water should differ significantly. Other factors, such as heavy rains, storm runoff in the coastal waters, upwelling of subsurface water, or extensive alterations in plankton population should produce additional differences (Southern California Coastal Water Research Project, 1973, p.125).

The information concerning the general concentration level of trace metals in the study area is limited to the following elements.

Cobalt	0.1 - 0.2	µg/l
Copper	1.6 - 9	µg/l
Iron	1.9 - 44.3	µg/l
Mercury	0.03	µg/l
Nickel	0.4 - 2.5	µg/l
Lead	0.4 - 18.2	µg/l
Zinc	1.1 - 41.2	µg/l

For most of these, the levels are consistent with those reported in other parts of the world's ocean, except for lead (Chan, 1974).

5. Hydrogen Ion Concentration

The concentration of the hydrogen ion is measured on the pH scale, where a pH value of 1 is very acidic, (high hydrogen ion concentration) 7 is chemically neutral, and 14 is very alkaline. The following is a summary of pH data for the Southern California Bight taken from Chan (1974).

The range of pH for the shelf water varies from about 7.5 to 8.6. The Allan Hancock Foundation showed that the pH of 65% of the 200 water samples collected had pH of the sea water decreases to a range of values between 7.6 - 7.8 (1965). High pH values at or near the sea surface are due to the equilibrium with the carbon dioxide in the atmosphere, but the maximum pH values may be caused by the photosynthetic activity of plants, which reduces the content of carbon dioxide in sea water. Below the euphotic zone, pH decreases as the concentration of carbon dioxide increases as a result of respiration and decomposition. In the oxygen minimum layer, there is a gradual increase in pH with depth. The pH of the water below the sill depth in the marine basins in the coastal borderland depends on the sill depth. Those basins having deeper sill depth will have higher pH values. The Santa Monica Basin has sill depth of 737 m, and the pH of the basin below sill depth ranges between 7.68 - 7.77, while the Catalina Basin, which has sill depth of 982 m, the corresponding range is 7.70 - 7.89 (Rittenberg, et al., 1955).

6. Light and Water Transparency

Light is important biologically because it provides the energy source for all photosynthesis and ultimately all biological

activity. Because the intensity of available light diminishes with increasing depth, light levels strongly affect the vertical distribution and migrations of plankton and of the vertical and horizontal zonation of attached marine plants such as kelp. A commonly used criterion of water transparency is the greatest depth at which a white metal disc, 30 cm in diameter (Secchi disc.) can be seen from the surface. The depth to which light is useful for photosynthesis has been estimated at about 2.5 times the Secchi disc depth. Along the California coast, the mean visual transparency varies from less than 6 m to more than 15 m; lower values occur close to shore. Within one mile of the coast, visual transparencies of less than 6 m are common opposite alluvial land plains; transparencies of 6 to 12 m are more typical off rocky shores (Allan Hancock Foundation 1965).

E. Biological Oceanography

1. Phytoplankton

a. Introduction

The purpose of this section on phytoplankton is to present a literature survey rather than to make definitive statements on primary production, species composition and community distribution, since these change day to day and year to year making the establishment of base line reference data prohibitive. Additional difficulties encountered are the natural phytoplankton community characteristics and inconsistencies in sampling procedures.

Chief among community characteristics is patchiness or unevenness in the distribution, composition, and abundance of phytoplankton. Patchiness is poorly understood apart from the fact that natural mortality, grazing, and blooms play important parts. Both large scale (distances of several hundred kilometers) and small scale (one to several hundred meters) differences occur in the vertical and horizontal distribution of abundance and species composition. Blooms alone, which are frequently sudden and of short duration, can cause major changes in composition in a period of two weeks or less. Consequently, the patchiness of the phytoplankton communities poses formidable sampling problems and makes it difficult to establish conclusively to what extent the results of an investigation are characteristic of the area being studied. See Appendix 10, Section II.E.1.a. for a discussion of sampling methods and analysis.

With these difficulties in mind, the following literature survey with its accompanying research references is presented as a summary of current qualitative formation on phytoplankton of the Southern California Bight area. The two main sources of California marine plankton data are the Scripps Institute of Oceanography and the California Cooperative

Ocean Fisheries Investigations at La Jolla. Section II.E.1.b. of Appendix 10 details the taxonomic phytoplankton studies in the Southern California Borderland to date. The following material is taken with minor alteration from R. Z. Riznyk of the Southern California Ocean Studies Consortium (1974).

The phytoplankton comprise all those unicellular and colonial photosynthetic organisms free-floating in the sea. They constitute the first trophic level of the food chain assimilating inorganic carbon, nitrogen, phosphorous, and a host of other elements into their protoplast upon which, ultimately, all animals of the sea depend. In addition to the various inorganic and organic nutrients, proper light intensities and temperatures are essential for their growth. A deficiency of any one or a combination of these requirements may limit their production. Comprising the phytoplankton are representatives of several algal groups: Chrysophyta (diatoms, coccolithophores, silico-flagellates), Pyrrophyta (dinoflagellates), Euglenophyta (euglenoids), Chlorophyta (green algae), Cyanophyta (blue-green algae) and Cryptophyceae (cryptomonads).

Although phytoplankton exist in all marine environments, the areas of greatest productivity are at the higher latitudes in spring and summer, along coastal boundary currents, and in the equatorial current system. The reason why these areas are highly productive is the presence of a mechanism bringing nutrients into the euphotic zone from deeper waters by the processes of diffusion, turbulent mixing, and upwelling. In terms of phytoplankton, areas of upwelling are approximately three times as productive as the coastal zone and six times as productive as the open ocean. (Table II-6).

The importance of phytoplankton in the ecology of Southern California

Table II-6

ESTIMATED PRODUCTIVITY IN THREE OCEAN PROVINCES
(From Ryther 1969)

	Province			
	Open Ocean	Coastal Zone	Upwelling Areas	Total
Percentage of Ocean	90	9.9	0.1	100
Area (sq km)	326×10^6	36×10^6	3.6×10^5	362×10^6
Mean Primary Productivity (g C/sq m-yr)	50	100	300	
Total Primary Productivity (M tons C/yr)	16.3×10^9	3.6×10^9	0.1×10^9	20×10^9
Assumed Number of Trophic Levels	5	3	1.5	
Assumed Efficiency (%)	10	15	20	
Fish Production (M tons/yr)	1.6×10^6	1.2×10^8	1.2×10^8	2.4×10^8

coastal and offshore areas involves three major aspects: 1) Their productive nature is of paramount importance as the base of the food chain and any change in their abundance or community structure will invariably affect subsequent portions of the chain; 2) Excessive enrichment or eutrophication of local areas may result in a phytoplankton bloom which can discolor the water, produce noxious odors, and interfere with the recreational potential of an area by decreasing its aesthetic value; 3) Their uptake of toxic materials which may enter the food chain is of utmost importance to the seafood industry and the welfare of man. The reader may read Section III.C.1.a. for a discussion of impacts on the phytoplankton.

b. Physiological Ecology

Since 1963, with the inception of a Marine Food Chain Research Group at the University of California's Institute of Marine Resources at La Jolla, a better understanding of the biology of marine phytoplankton has been obtained.

As a necessary prelude to their work on phytoplankton physiology, was the establishment of a culture collection with representative phytoplankton species numbering over 100 from all divisions. The collections are now standardized and are maintained in special holding incubators.

Off the coast of Southern California the phytoplankton are subjected to a periodicity of light and darkness which may have some effect on the growth rate. A series of papers based on culture experiments have described the behavior of phytoplankton grown under intermittent illumination (Eppley and Coatsworth, 1966; Paasche 1967, 1968a, 1968b; Eppley et al., 1967). A daily light-dark cycle has been found for all algae examined which cause the cells to divide once a day but the timing of the cycle depends on the temperature and light intensity and is species specific. *Coccolithus huxleyi* always divides in the dark. The diatoms *Ditylum brightwellii* and *Nitzschia turgidula* divide during the day. The growth of all species studied increased with an increase in the length of illumination, but this relationship was not linear. Above 16 hours of light there was no increase in growth rate and in the cases of some diatoms it was actually inhibitory.

As a result of having measured the growth rate of a wide variety of marine phytoplankters, Eppley and Sloan (1966) were able to relate growth rate to the size of the cell and its chlorophyll content. They assumed that the light absorbed by chlorophyll α in a unit volume of cell substance was utilized to produce a steady state of substrate (S) and that this substrate governed growth kinetics by an equation:

$$\text{Rate} = \frac{\text{rate}_{\text{max}} S}{K + S}$$

where K is a constant and rate_{max} is the maximum possible rate at that temperature.

Marine centric diatoms decrease in size on repeated division and eventually become smaller and smaller on successive divisions unless they

reenlarge by a process involving auxospore formation (i.e., spores formed by sexual fusion). This process is critical in the ecology of planktonic diatoms if they are to remain successful. It has been shown in two clones of *Coscinodiscus* that the valve morphology changed sufficiently before and after the auxospore stage for different "species" to be produced (Holmes, 1966, 1967; Holmes and Reimann, 1966). Auxospores were found only in a narrow range of temperature and light and hence successful reproduction could occur only in a restricted regime of temperature and high light intensities.

One problem in phytoplankton physiology has been to determine what affects the natural concentration of plant nutrients in sea water.

In the normal marine environment phosphate levels are never limiting to phytoplankton growth and it appears that nitrogen is the main limiting nutrient. (See Sect. II.D.1. for a description of nutrients.) A relation between the abundance of diatoms and the quantity of nitrate has been recognized in Southern California with regard to upwelling since 1928 (Moberg, 1928). Sverdrup and Allen (1939) and Sargent and Walker (1948) also found relationships between planktonic diatom abundance and recently upwelled water having a shallow thermocline.

The question as to whether or not plants utilize ammonia or nitrate has been studied by Eppley et al. (1969) from an enzymatic point of view. The presence of the enzyme nitrate reductase was found to be a sensitive indicator of whether or not natural populations were using nitrate from the environment. The dinoflagellates in the red tides off La Jolla were found to be swimming down to a nitrate layer for their sustenance. However, ammonia was assimilated in preference to nitrate

by plankton if both were present. The enzyme was not induced until most of the ammonia in the water has been utilized and its concentration reduced to about 0.5 $\mu\text{g-at N/l}$. K_s values, which reflect the ability of an organism to utilize low levels of nutrient, were evaluated for 16 species and found to be dependent on cell size and growth rate (Eppley, et al., 1969). Small oceanic species had the lowest K_s values for nitrate and coastal dinoflagellates had the highest. Using these kinetic concepts Eppley (1970) has attempted to predict the species distribution off the La Jolla coast. He hypothesized that: 1) The distribution of some ubiquitous species as *Coccolithus huxleyi* should be independent of nitrate availability because of their ability to utilize low concentrations of ammonium; 2) The distribution of other diatom species should be dependent on the amount of nitrate in the euphotic zone because of their high K_s value for ammonium and because of low ammonium concentrations in this zone; 3) The distribution of motile dinoflagellates such as *Gonyaulax polyedra* is less dependent on the depth distribution of nitrate because of its ability to migrate vertically in the water column over 10 to 15m in a 24 hour period (Eppley et al., 1968).

Besides ammonium and nitrate, marine phytoplankton have been shown to utilize urea as the sole source of nitrogen (McCarthy, 1971). Several species of neritic diatoms were found capable of utilizing concentrations similar to that found in the marine environment based on K_s values and short term growth experiments in culture (McCarthy, 1972a). Rates of nitrate, ammonium, and urea uptake for natural assemblages of phytoplankton were determined off the Southern California coast during a cruise in July 1970 (McCarthy, 1972b). It was found that 28% of the total nitrogen

was taken up as urea. At some stations where only a small fraction of the urea was utilized, it may be possible that urea uptake was suppressed by the presence of ammonium (McCarthy and Eppley, 1972). See Section II.E.1.C. of Appendix 10 for a discussion of vitamin uptake and requirements for phytoplankton.

c. Ecology

The study of phytoplankton ecology in Southern California had its inception at the Scripps Institute of Oceanography in 1917. At this time W. E. Allen was induced to make a preliminary survey with the intention of possibly developing food resources for war time needs by examining the marine food chain. In 1919 a series of daily collections was begun at the Scripps Institute pier and at Pt. Hueneme 100 miles further north and continued for 20 years. These series of collections were supplemented by pier collections from other localities in Southern California namely Oceanside, for a period of 5 years, and in Balboa, for a period of 3 years. The data obtained from these stations were used for estimating the occurrence of phytoplankton biomass. Since 1938, collections of phytoplankton from cruises had supplemented the pier work. In the 20 years that Allen pursued his research more than 25 papers have been published dealing with the phytoplankton material that he collected. (Allen, 1921a, 1921b, 1922a, 1923a, 1923b, 1923c, 1923d, 1923e, 1924a, 1926, 1927d, 1930b, 1933a, 1940a, 1941, 1945a, 1945b, 1945c.) Briefly summarizing his results he noted: (1) Biomass was generally greater at his northern station at Pt. Hueneme than at his southern station in La Jolla. (2) An increase in biomass began and ended a few weeks later at Pt. Hueneme than in La Jolla. (3) Initially it was thought that the biomass was greater within a few miles of shore than in oceanic waters but later it was found that this effect was only periodic. (4) Maximum

numbers of phytoplankton were found at subsurface levels between 30 to 60 feet in shallow water and 60 to 90 feet in deeper water. (5) A correlation was noted between the nutritive influence of the Los Angeles City sewage outfall and the large population of phytoplankton near Pt. Vincente. (6) In 20 years of daily collecting only 100 species representing 41 genera were identified. Of these only 17 species were dominant, the genus *Chaetoceros* having the greatest total abundance. (7) There is considerable variability in the annual biomass of planktonic organisms in Southern California. (8) Localities studied differed in biomass of diatoms and dinoflagellates from year to year. (9) Dinoflagellates may be found almost anywhere in Southern California coastal waters but their numbers are mostly below 1000/l. (10) Only 4 species of dinoflagellates ever obtained dominance: *Prorocentrum micans*, *Gonyaulax polyedra*, *Ceratium furca*, and *Ceratium tripos*. (11) Large numbers of dinoflagellates are confined to levels above 30 m and to a zone within 25 miles offshore. (12) At Scripps pier almost every species of diatom known to occur in the East Pacific was found. (13) During a 20 year period no two years, no two weeks, and no two days were alike with regard to phytoplankton biomass. (14) The existence of productive localities 100 miles from the shore at depths of 50 m has been demonstrated. (15) A lack of regularity in depth distribution was shown. (16) The annual production tends to be the greatest in the spring.

During a period of unexpected warm water off La Jolla in 1957 a study was made (Balech, 1960) to compare the phytoplankton flora that was then present to that of the 1938-1939 collections of Allen when the water temperatures were found to be lower than normal. It was shown

that warm water and tropical phytoplankton were abundantly represented when they were largely absent in 1938-1939 and the appearance of cold water forms was delayed and restricted.

The greatest percentage of ecological studies on phytoplankton has been related to the effects of nutrients from the marine outfall areas. Stevenson and Grady (1956) measured the volume of plankton around the Hyperion, Whites Point and Orange County outfalls and noted an increase in volume within 300 m from the point of discharge (Fig.II-26

Between 1957 and 1959, the Allan Hancock Foundation of the University of Southern California made a quantitative and qualitative study of the microplankton off the Southern California mainland shelf (Resig, 1961). The sampling program encompassed areas that were affected and unaffected by the sewage outfalls. More than 60 species of diatoms representing 27 genera were recorded but only 12 species of diatoms achieved abundance during the survey. The genus most commonly represented was *Chaetoceros*. Twelve genera of dinoflagellates were observed, the most abundant species being *Prorocentrum micans*. A high degree of variability in plankton counts resulted, so the logarithms of counts were recorded which should approximate the normal distribution. Counts of cells at 30 to 40 m were alike but substantially lower than at shallower depths (0 to 16 m). At still greater depths the counts declined even further. These results differ from Allen's in which he noted that 30 m is the level of maximum plankton number. Differences may be due to species encountered. It has been noted for example that *Rhizosolenia styliformis* prefers the depth range from 50 to 150 ft. whereas the principle range of *R. alata* was from the surface to 50 ft. With regard to the dinoflagellates the counts

AVERAGE PLANKTON VOLUME PER
NET TOW THROUGH 50 FEET OF WATER

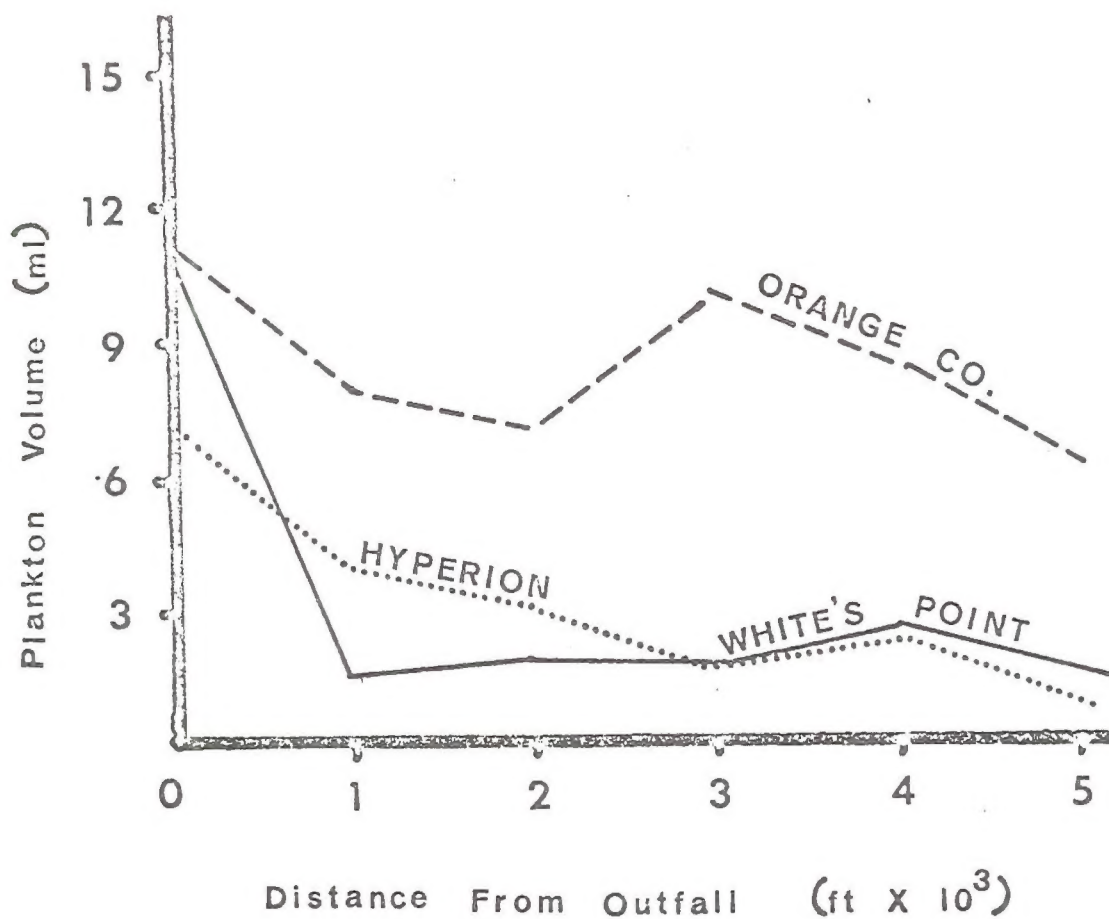


Figure II-26 Plankton volume versus distance from 3 sewage outfalls.
After Allan Hancock (1965).

at 16 m were half that at 0-8 m. Seasonally speaking, the diatom numbers were found to be higher in summer than in winter (Fig. II-27) and the dinoflagellate data show less dependence on the season. Viewing the data obtained it was concluded that for no species was there a demonstrated dependence on latitude since the patterns of water movement make the Southern California shelf waters quite uniform from Point Conception to the Mexican border.

To assess the effects of ocean outfalls on the phytoplankton, arbitrary distances of 5 miles from the Los Angeles City and Los Angeles County outfall were selected as working sites. There was no difference between dinoflagellate counts in and out of the affected areas. Diatom counts appear to be higher near the large outfalls (Fig. II-28). In a study performed during July 1970 (Eppley et al., 1972) definite evidence was found of eutrophication of the sea near the Point Loma outfall and the Whites Point outfall. Their conclusions were based on the fact that the outfall areas were highly productive as seen by depth profiles of chlorophyll *a* when compared with the two control areas (Fig. II-29). They noted that the outfall areas also showed a much higher primary productivity than the control stations (Fig. II-30). Daily production integrated over the euphotic zone was 1.8 and 2.6 g C/day which is two to three times the seasonal averages off La Jolla (Table II-7). It was quite surprising to the investigators that concentrations of nutrients and dissolved organic matter were not any greater in water samples taken at the outfall areas. This would imply that the hydraulic diffusers were effective in diluting wastes prior to emission and/or that phytoplankton growth was sufficiently vigorous to deplete the waters of excess nutrients.

PERCENT PLANKTON FROM AUGUST 1955 - JULY 1956

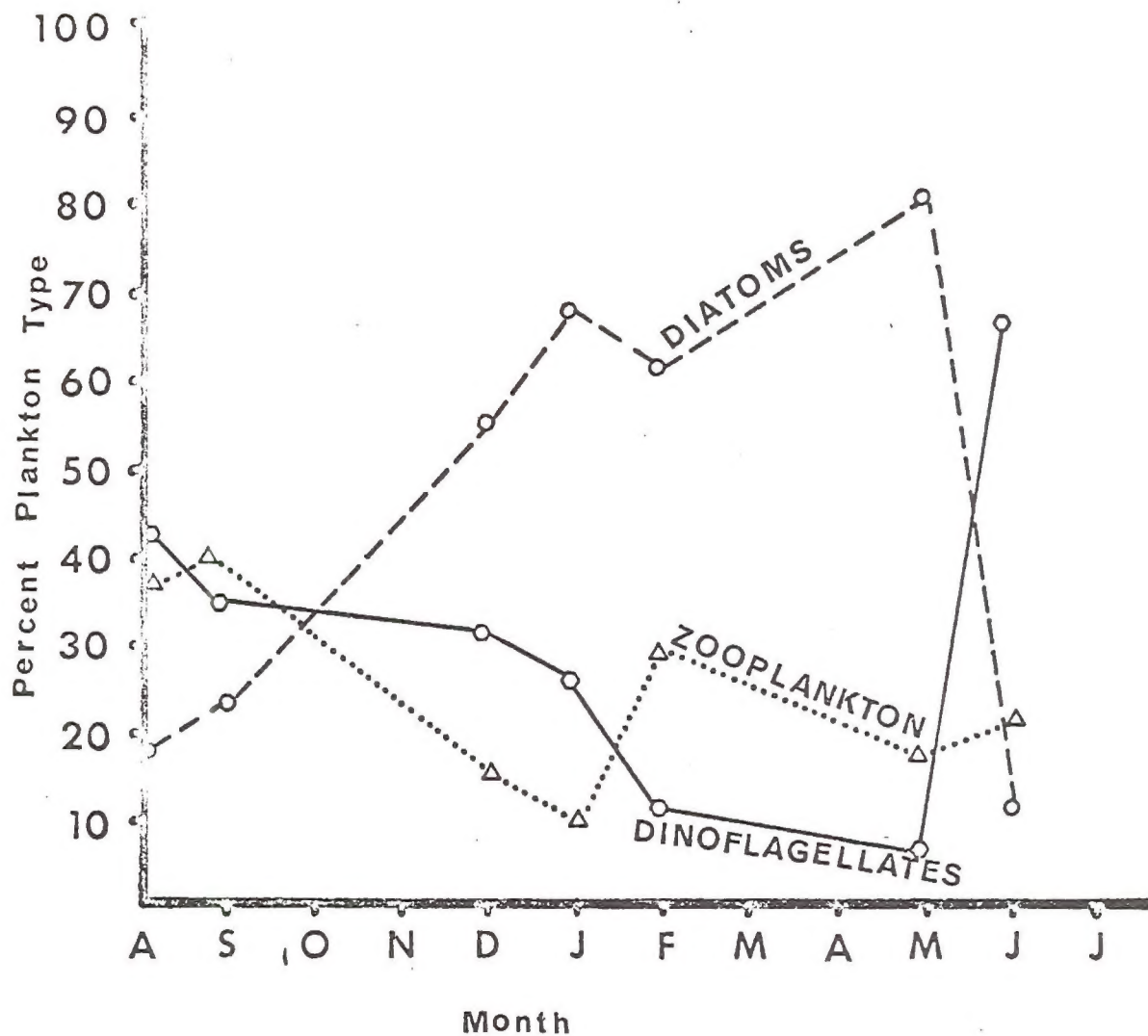


Figure II-27 Variation in 3 groups of plankton from August 1955 to July 1956. After Allan Hancock (1965).

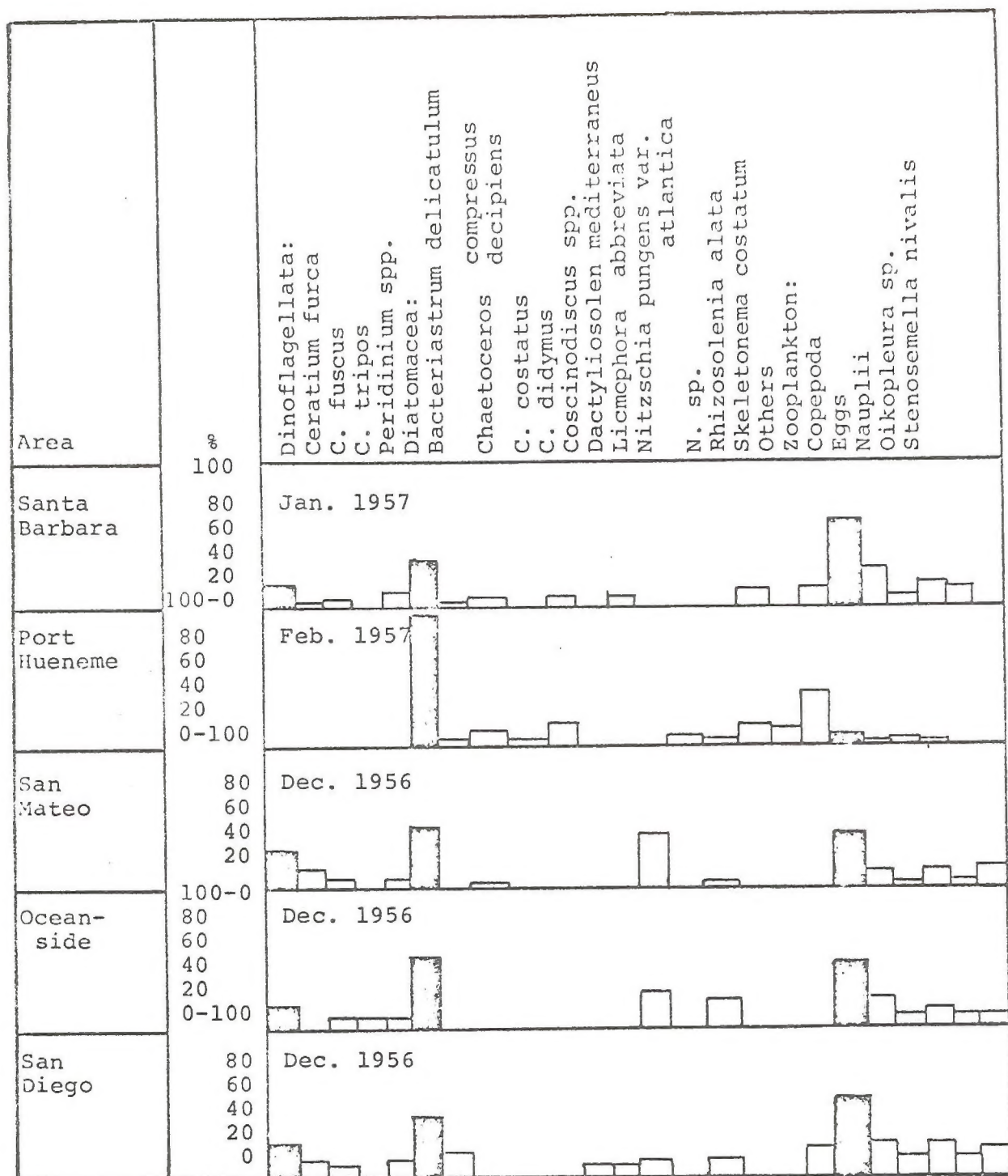


Figure II-28 Distribution of planktonic species from 5 southern California localities. After Allan Hancock (1965).

CHLOROPHYLL a IN OUTFALL AND NON-OUTFALL WATERS

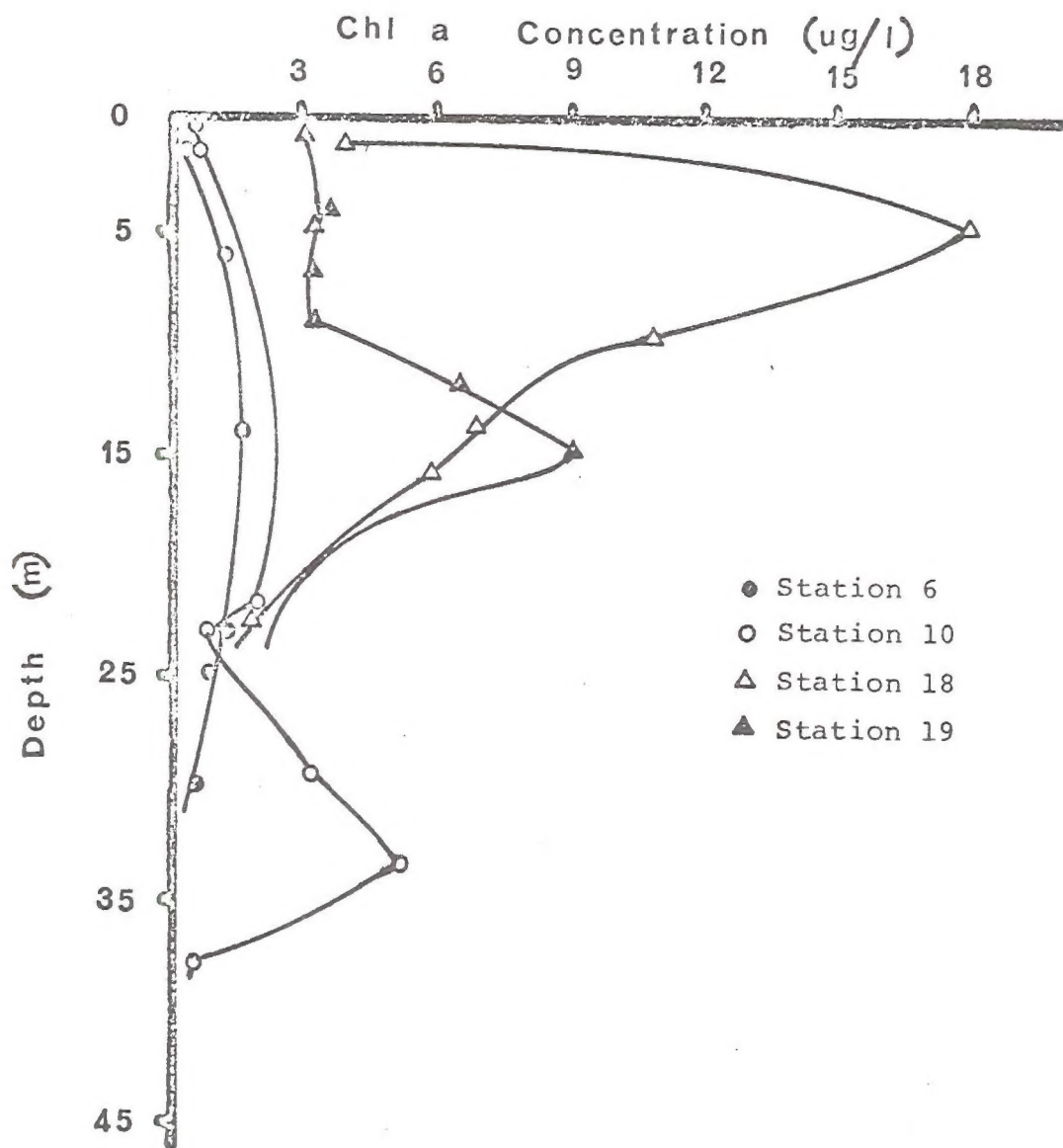


Figure II-29 Concentrations of chlorophyll a in waters from stations 6 and 10 (non-outfall) and 18 and 19 (outfall). After Eppley et al., (1972).

PRODUCTION IN OUTFALL AND NON-OUTFALL WATERS

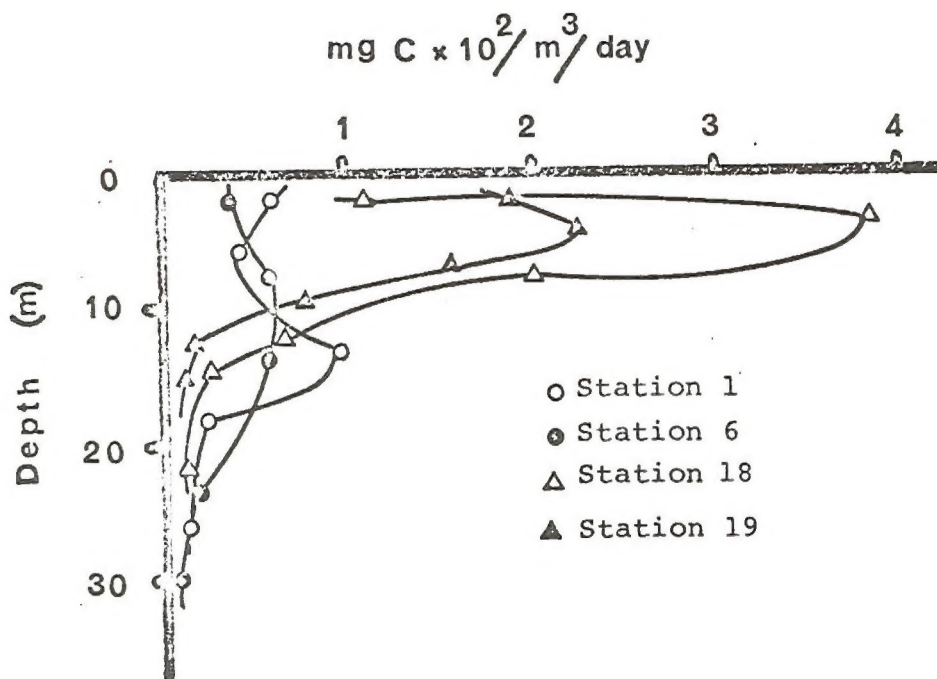


Figure II-30 Production in waters from stations 1 and 6 (non-outfall) and 18 and 19 (outfall). After Eppeley et al. (1972).

Table II-7

COMPARISON OF PHYTOPLANKTON CROP AND PRIMARY PRODUCTION,
 INTEGRATED OVER THE DEPTH OF THE EUPHOTIC ZONE, FOR
 STATIONS NEAR SCRIPPS CANYON, THE PT. LOMA (SAN DIEGO)
 AND WHITES POINT (LOS ANGELES) SEWAGE OUTFALLS.
 (After Eppley et al., 1972)

	Station					
	Pt. Loma		White's Pt.	Scripps Canyon		
	12	18	19	1	6	10
Phytoplankton carbon (g/m ²)..... (as 250 x ATP)	14.9	12.1	5.9	8.4	4.4	3.6
Chlorophyll <u>a</u> (mg/m ²)		163	83	40	30	29
Primary production (g C/m ² /day).....		2.64	1.76	1.37	1.10	0.36
Specific growth rate (doublings/day)		0.28	0.37	0.26	0.32	0.13
Depth of euphotic zone (m).....	18	21	16.5	33	33	46

No toxic effects of sewage effluent on phytoplankton were noted.

During another Food Chain Research Group cruise in June 1971 to the Point Loma and Whites Point outfalls, phytoplankton productivity and chlorophyll were not particularly enhanced as compared to a control station off La Jolla (Thomas, 1972). During this cruise ammonium levels were found to be high, particularly at the subsurface levels at Whites Point so perhaps the nitrogen had not yet been assimilated to produce a high crop and high production. These contrasting years suggest that even a relatively constant input of nutrients by outfalls may not result in a constant degree of eutrophication. Further work conducted by Thomas (1972) in relation to sewage outfalls and phytoplankton consisted of three parts: 1) measurements of chlorophyll, nutrients, and primary productivity near outfalls; 2) nutrient enrichment experiments; and 3) algal bioassays. He found that discharge of waste waters by Southern California sewage outfalls results in the enrichment of ocean receiving waters of phytoplankton nutrients. This enrichment results in moderate eutrophication as defined by the increase in the phytoplankton standing crop. Chlorophyll measurements indicate standing crop values of phytoplankton three - to four-fold greater than at control locations or further than one mile away from the larger outfalls. The extent of eutrophication is limited to within 5 miles of the largest outfalls at Whites Point and occasionally Hyperion.

Eutrophication was apparently due to nitrogen input from high ammonium concentrations of sewage into a nitrogen-limiting system. Eutrophication is lessened somewhat by the seasonally effective nutrient trapping below the thermocline and by a reduced euphotic depth in the area of the outfall. A bioassay of sub-thermocline waters showed a 4 - to 25-fold

growth enhancement as compared to surface waters. Primary limitation of nitrogen was shown for near-shore waters by enrichment experiments with the addition of nitrogen consistently stimulating growth of phytoplankton communities. Sewage at a 1:200 dilution was also stimulatory to phytoplankton growth. Bioassays of phytoplankton cultures with outfall surface receiving waters showed some inhibitory properties but no consistency was found in the three algal species tested.

Between 1958 and 1966, plankton studies were conducted in the vicinity of the City of San Diego wastewater discharge off Point Loma (Marine Advisors, 1963; Water Resources Engineers, 1965). The only organism showing a consistent decrease was *Noctiluca*, a dinoflagellate. The diatoms *Skeletonema costatum* and *Mastogloia* and the dinoflagellates *Dinophysis*, *Prorocentrum* and *Oxytoxum* all appeared to increase as a result of the discharge. *Gonyaulax* ranked high in frequency both before and after the initiation of the waste discharge.

Between 1957 and 1970 the City of Los Angeles collected plankton data in the Santa Monica Bay area to provide a basis for determining whether the Hyperion wastewater discharges affect plankton productivity or species composition. During this 14 year period the wastewater discharge rate increased from 260 to 340 mgd and the outfall system was changed from a 1-mile outfall at a depth of 14-18 meters of water to a 5 mile outfall located at a depth of 60 meters. Fig. II-31 shows a comparison of the mean annual plankton volumes obtained from the Santa Monica Bay surveys with the plankton volumes obtained in the CALCOFI program for the same years (see Seapy, 1974 for the complete CALCOFI data). The same trends are apparent in both studies. Between the years 1962

PLANKTON ABUNDANCE IN SANTA MONICA BAY

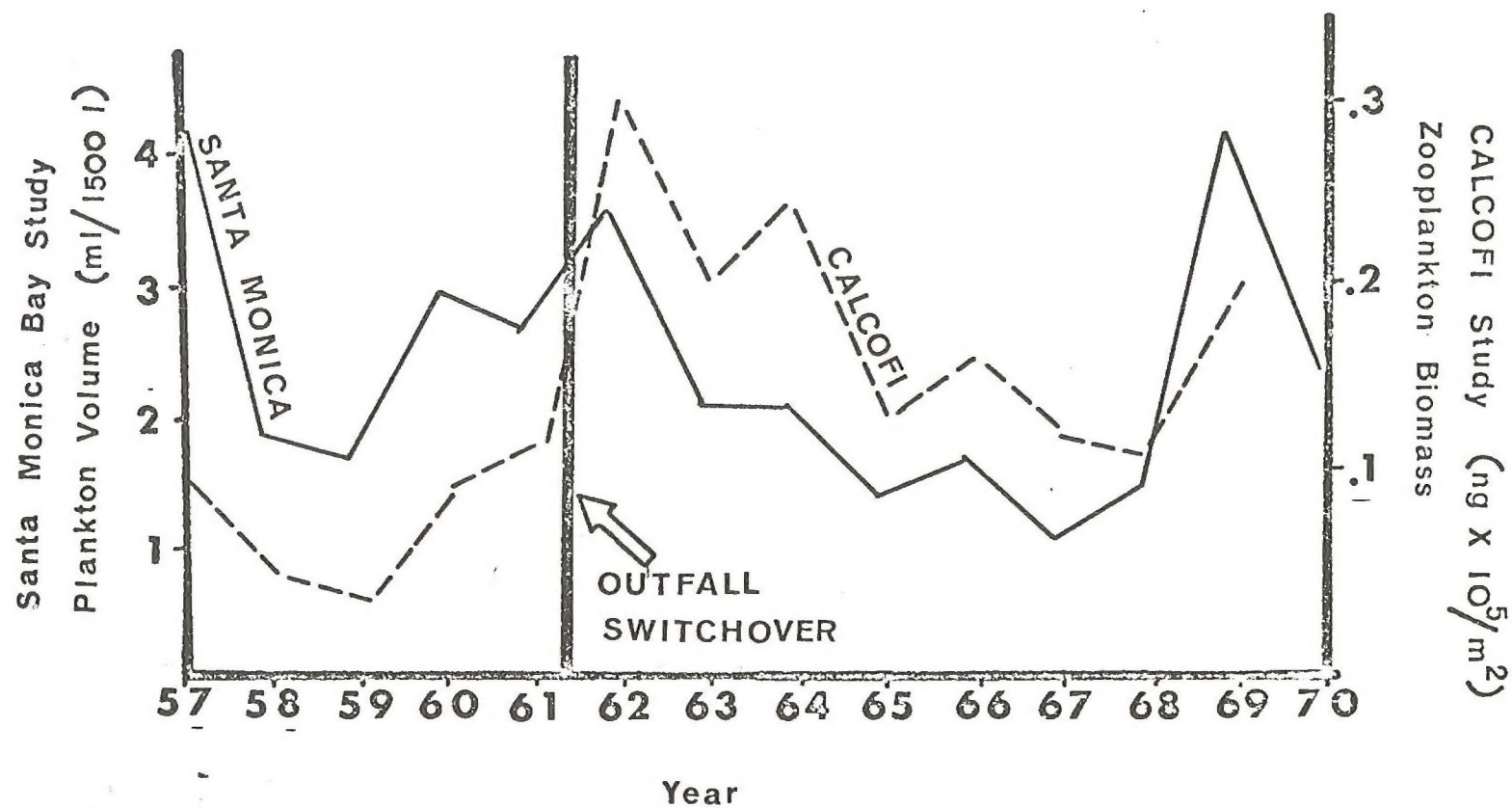


Figure II-31 Variations in plankton abundance in Santa Monica Bay. After Southern California Coastal Water Research Project (1973).

and 1968 the plankton volumes in Santa Monica Bay are smaller than would be expected on the basis of the CALCOFI data. This is attributed to the effect of the deeper outfall installation. During the period 1957 to 1959 when the old shorter outfall was in operation, the maximum plankton volumes were observed just beyond the end of the outfall (Fig. II- 32). When both outfalls were in operation the maximum volume had increased slightly. From 1962 to 1970 when only the new 5-mile outfall was in operation (Fig. II- 32), the maximum plankton concentration was offshore and southwest of the end of the new outfall.

Analysis of specific organisms in the Santa Monica Bay plankton sampling program indicates that over the period of time that the study was performed, two diatoms, *Chaetoceros* and *Dactyliosolen*, increased in relative dominance and the diatoms *Ditylum* and *Achnanthes* decreased. Among the dinoflagellates *Noctiluca* increased and *Ceratium furca* decreased. *Gonyaulax* showed no consistent trend with regard to increasing or decreasing and was variable throughout the study period.

The ecology of the coastal phytoplankton of La Jolla was studied over a five month period in 1967. Productivity was measured and the phytoplankton catalogued at three stations corresponding to 0.75, 2.5 and 6.5 miles offshore. Both standing stock and productivity depended greatly on meteorological conditions, increasing after upwelling had shoaled the thermocline and trophocline (Eppley et al., 1970). The seawardmost station showed the lowest crop, carbon:chlorophyll ratio and primary production, but had the highest specific growth rate. Heterotrophic species as *Peridinium depressum* accounted for 5-10% of the crop at all stations most of the time. There was a close relationship

PLANKTON DISTRIBUTION IN SANTA MONICA BAY (ml/1500 l)

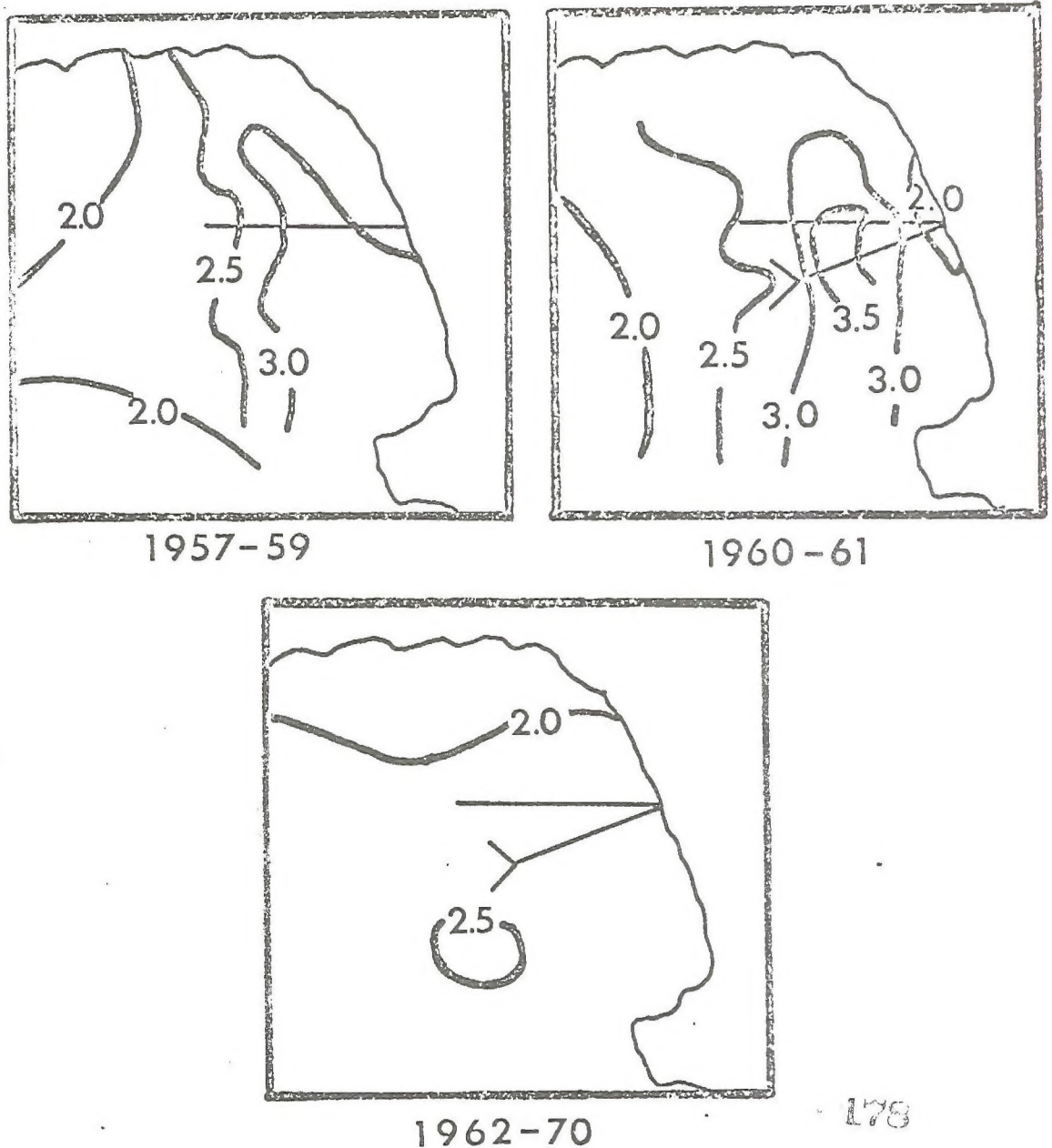


Figure II-32 Distribution of plankton in Santa Monica Bay during 3 discharge periods, 1957-59, 1960-61 and 1962-70. After Southern California Coastal Water Research Project (1973).

between species composition and nitrogenous nutrients (Eppley, 1970), the diatoms being clearly associated with nitrate in the water at depths where the light intensity was still high. The flora has been described in detail (Reid et al., 1970) showing a seaward change in abundance and species composition. Except after periods of upwelling, dinoflagellates and monads predominated. The major part of the plant biomass was in cells with diameters between about 10 and 50 μ and generally four species contributed an excess of 50% of the total cell carbon.

d. Red- Tides

Red tides are a natural phenomenon occurring in warm and temperate waters in many parts of the world. Along the Southern California coast the waters may become discolored with considerable frequency. This discoloration has been reported to range in color from white (Stracham, 1970) to yellow (Lackey and Clendenning, 1963) to red (Allen, 1938b). Dinoflagellates are reportedly the causative organisms responsible for discolored water even though diatom blooms could easily impart a red-brown color to the water.

The best studied locality of the red-tide phenomenon is the San Diego area. Since 1917 there have been many accounts of discolored water published for this region. Red tides were reported for the years 1924, 1929, 1933, 1938, 1942, and 1945 by Allen (1933c, 1935, 1938b, 1940b, 1942, 1943, 1946). *Prorocentrum micans* was responsible for four of the tides and *Gonyaulax polyedra* for three of them. One tide was caused by an unknown dinoflagellate. It has been suggested that *P. micans* is associated with red-water outbreaks before midsummer while *G. polyedra* is associated with red-water outbreaks after midsummer.

Since 1964, a number of observations have been made on red tides by the Food Chain Research Group of the Institute of Marine Resources in La Jolla (Holmes et al., 1967). They have reported five blooms occurring in La Jolla Bay between May 1964 and December 1966. Organisms responsible for these blooms were *P. micans*, *G. polyedra* and unidentified species of *Gymnodinium* and *Cocholdinium*. During the day the organisms appeared in discrete patches that dispersed at night. Blooms were found to decline due to an increase of dissolved organic carbon and ortho- and monophosphate esters. One bloom was decimated by zooplankton grazing. A steep shallow thermocline was shown to be associated with the blooms. Maximum cell concentrations were 20×10^6 cells/liter in May 1964.

G. polyedra is non-toxic to fish as long as it is in a healthy condition. When this organism undergoes putrifactive decomposition, fish are killed as a result of an oxygen deficit (Clendenning, 1959). Man-made harbors in Southern California have increased the threat of fish kills. A reduced circulation has resulted in semi-stagnant conditions which create virtual fish traps during intense dinoflagellate blooms. At times the dissolved oxygen levels are reduced to zero during the time when the bloom is decaying. The problem is compounded by the decay of dead fish which uses up more oxygen. The fish and invertebrates probably suffocate since the dinoflagellate species causing the red-tide are not known to be toxic (Carlisle, 1968). The absence of the mussel poisoning species *Gonyaulax catenella* has been established for several samples of red-tide water. This organism is restricted to the colder water north of Pt. Conception where mussels and other mollusks concentrate the toxin in their digestive gland after ingesting the dinoflagellate.

Fish kills which have been attributed to red-tides have occurred in Mission Bay during July 1961 where the causative organism was *Gymnodinium flavum* (Lackey and Clendenning, 1963) and in Santa Monica Bay in 1945 where the causative organism was *Polykrikos schwartzii* (Brongersma-Sanders, 1957). In 1964 a tremendous bloom of *G. polyedra* killed anchovies, mussels, and barnacles at Marina Del Ray, Redondo-King Harbor, Long Beach Harbor, Camp Pendleton Harbor and Oceanside Marina (Carlisle, 1968).

The mechanisms which trigger and sustain dinoflagellate blooms are little understood despite a great deal of research. Red tides seem to occur when ocean nutrients are extremely low and often a red-tide will follow a diatom bloom. Organic pollution has been ruled out as a cause of the red-tide since records of red-tides along the coast of California extend as far back as 1746 long before any urban developments with sewage outfalls (Clendenning, 1958). A correlation between red-tide occurrences and offshore Santa Ana winds has also been mentioned.

e. Summary

The study of phytoplankton in Southern California dates back to the early 20th century with the work concentrated on the taxonomy of dinoflagellates. Due to an interest in marine resources a program was developed at the Scripps Institution of Oceanography involving daily pier collections which were analyzed for standing stock. Problems identifying the species encountered led to a taxonomic monograph on the plankton diatoms.

Most ecological research has been with regard to the effect of sewage outfalls on species composition, standing stock and productivity. Generally it has been noted that production and standing stock is higher in

outfall areas than in control areas. No consistent change in species composition has been noticed. No relationship has been established between the red tide and sewage outfalls.

With the initiation of a Food Chain Research Group at the Institute of Marine Resources a greater insight into the physiological ecology and biochemistry of phytoplankton has been recognized. Their work on the excretion and uptake of vitamins and on nitrogen relationships of phytoplankton, both in culture and in natural populations, have increased the knowledge of phytoplankton dynamics.

2. Zooplankton

a. Introduction

Except for minor changes and additions, this section is taken from R. Seapy (1974) of the Southern California Ocean Studies Consortium. A discussion of impacts on this topic may be found in Section III.C.1.a.

The zooplankton is a diverse assemblage of heterotrophic organisms sharing the common attribute of limited swimming abilities. It includes both the holoplankton, which lead a planktonic existence at all stages of their life cycles, and the meroplankton, which live in the plankton for only a part of their life cycle. For example, various reproductive stages of bottom dwelling organisms are represented in the meroplankton.

The neritic zooplankton in waters overlying the expanded continental shelf (or borderland) off Southern California comprise a transitional fauna (McGowan, 1968 and 1971). The Southern California borderland is located in an area of water mass transition, and the sources of these waters can be traced to the Subarctic Pacific (to the north), the Eastern Central Pacific (to the west), and the Equatorial Pacific water masses (to the south). The zooplankton populations occurring over the borderland include native species as well as the fringes of large populations located in the adjacent waters masses. Therefore, the assemblage of species is heterogeneous through the bathypelagic zone (McGowan, 1968 and 1971; Ebeling et al., 1970a).

The species composition and distribution of the zooplankton in

waters overlying the Southern California borderland are known from only a limited number of studies. These studies span a broad period of time and only occasionally overlap for any given year. Fortunately the majority of these studies share a common denominator that allows comparisons of data. Since zooplankters are collected either by a net or a pump, the volume of water sampled is normally monitored and the raw counts of individuals by species can be converted to numbers of individuals per unit volume of water (expressed as numbers per m^3 for nearshore and estuarine zooplankton and numbers per 1,000 m^3 for offshore neritic and oceanic zooplankton). However, zooplankters are generally recognized to have a patchy or contagious distribution in space (Cushing, 1962; Weibe, 1970) and the representation of abundances in the above manner is probably not accurate since it actually represents a "mean" density and assumes a random spatial distribution through the volume of water sampled. Because actual numbers at a specific point in the water column can not be determined by the above indirect sampling methods, one can partially avoid the problem of accounting for the variability between true population densities and the "mean" density estimate by grouping counts into ranges of densities that become broader as the density values become higher. This method has been adopted from the California Cooperative Oceanic Fisheries Investigations program for the present report, and each range of densities has been given an abundance value (see Table 8-1 in Seapy, 1974).

While the basic objective of this review was to summarize the literature on zooplankton off Southern California, Seapy's report goes

far beyond this by establishing an actual data base from the known literature. This was accomplished by adopting and extending the density range concept of the California Cooperative Oceanic Fisheries Investigations program (discussed above) to enable the translation of quantitative data from a variety of sources into a common format. Where the volume of water sampled was not measured, separate tables had to be constructed. A computer program was written to accept abundance data for the different taxonomic groups, dates, sampling location and literature sources. The tabular printouts from this program can be found in Seapy (1974). See Section II.E.2. of Appendix 10 for a description of zooplankton sampling programs and literature sources.

b. Review of the major zooplankton taxa

i. Coelenterata-Hydrozoa

Published records of hydrozoan medusae and siphonophores from the study area were not found in the literature. However, this group was included by Alvarino (1967) in a study of vertical distributions south of the study area (at $30^{\circ} 30'N$ Lat, $120^{\circ} 00'W$ Long) in late August and early September of 1965. Abundances (numbers per $10,000\text{ m}^3$) for each species at a series of selected depth intervals were included for the medusae, while qualitative records were presented for the siphonophores. These data are useful for indicating the probable species composition over the Southern Offshore Area (see Fig. II-33) during the late summer months.

Reports of Ctenophora from the study area were not identified, although it is common knowledge at one species, *Pleurobrachia bachei*

is frequently encountered in the nearshore plankton off Southern California. This species was collected off La Jolla by Hirota (1917) for laboratory studies of growth and metabolism. In oceanic waters, unidentified species of *Beroe* were reported from south of the study area by Alvarino (1967). *Beroe* spp. were collected to depths of 525 m, and occurred at densities of (less) than 50 individuals per 10,000 m³ in the upper 110 m of the water column.

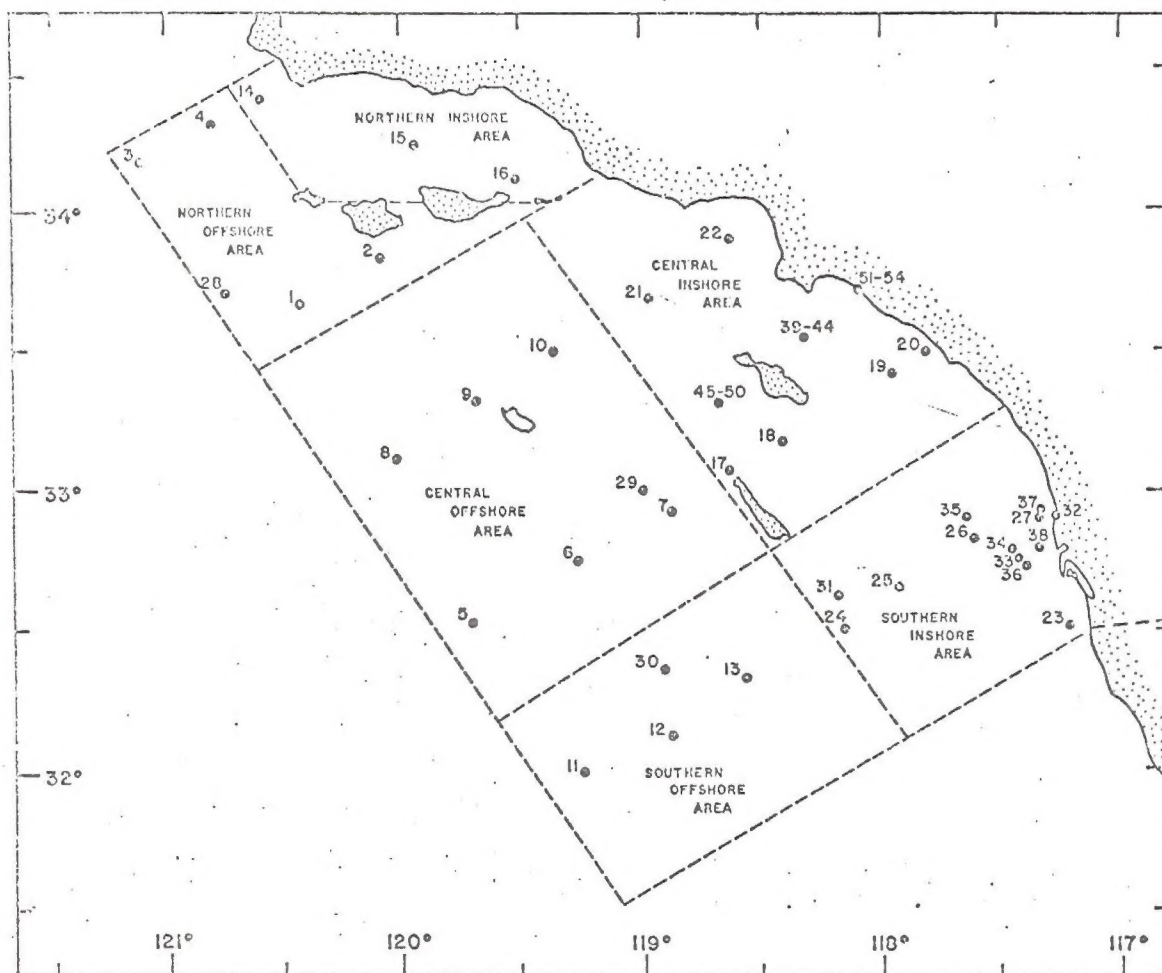


Figure II-33. Sampling locations for cited studies and their assigned station numbers off Southern California. Stations are grouped into 3 inshore and 3 offshore areas. The southwesterly boundary of the study area roughly parallels the Patton Escarpment. From: Seapy (1974)..

ii. Chaetognatha

Records for the chaetognaths are available from both nearshore and offshore areas. The CalCOFI samples representing oblique 1 m net tows to 140 m were analyzed for chaetognaths by Alvarino (1965) for all months of 1954 (except September and November) and January to July and October of 1958. See Table 8-3 in Seapy (1974) for data. The most abundant species were *Sagitta euneritica*, *S. bieri*, *S. minima*, and *S. enflata*. No pattern of seasonality or inshore-offshore differences in abundances were evident from the data.

Additional data for chaetognaths in offshore waters was published by Alvarino (1967) from south of the study area. This study is noteworthy for its inclusion of species at depths greater than 140 m (the maximal depth of sampling in the CalCOFI program).

Abundance data for 4 species of *Sagitta* in Anaheim Bay were presented by Felts (1973) (See Table 8-3 in Seapy, 1974). The most important species was *Sagitta euneritica* which was present in high numbers, irrespective of season.

iii Polychaeta

Records of pelagic polychaetes from the first years of the CalCOFI program (1949-1950) were presented by Dales (1957) in a systematic and distributional review of the known species from the Pacific Ocean. Most species were captured infrequently by the oblique 1-m net tows to a depth of 75m (1949) and to 140m (1950) off the coast of California and northern Baja, California. Because they were captured in low numbers, Dales presented general distributional patterns based on combined cruise records, with the exception of the July 1949 records

for *Tomopteris elegans* and *Tomopteris septentrionalis*. A summary of these distributional records is presented in Table II-8. All species are listed which could conceivably occur in plankton samples off Southern California. Comments concerning their distributions and abundances are included. When a species was recorded over the defined study area for this report (Fig. II - 33) its location was included in the distributional remarks.

Additional records of pelagic polychaetes off Southern California are from Seapy (unpublished data) in surface waters southeast of San Clemente Island overlying the Velero Basin. During August 1967, 7 and 20 *Tomopteris elegans* per 1,000 m³ were captured in two nighttime tows taken with a 10-ft IKMT at 13-m depth. *Vanadis formosa* was captured in low numbers (1 per 1,000 m³) in each of the tows.

iv. Mollusca - Pteropoda and Heteropoda

The pelagic pteropods off Southern California are known from the CalCOFI records of McGowan (1967). This material was also used (McGowan, 1968) to describe the thecosomate and gymnosomate pteropods from the California Current region of California. The data from McGowan (1967) for waters off Southern California are presented in Table 8-5 in Seapy (1974). The most abundant species was *Limacina helicina*.

The heteropods off Southern California have been reported from the CalCOFI records by Dales (1953) and McGowan (1967), and from the collections of the R/V VELERO IV and R/V SWAN by Seapy (1974). The CalCOFI data off Southern California from McGowan (1967) are presented in Table 8-6 in Seapy (1974). The most abundant species of heteropods

Displacement volumes of zooplankton samples (in ml/1,000 m³) collected during the CalCOFI cruises of 1951 to 1966 were reported by Smith (1971) as plots of volumes over the sampling area. Median zooplankton volumes were computed and plotted for selected months during the 16-year period. These data indicated that 64-256 ml/1,000 m³ of zooplankton were present over the study area off Southern California during February to July, while a large patch of lower volume (16 to 64 ml/1,000 m³) occurred over the study area in October and January.

Table-II-8

PELAGIC POLYCHAETES OFF CALIFORNIA AND NORTHERN BAJA CALIFORNIA
(COMPILED FROM DALES, 1957).

Species	Distributional Remarks
Family Phyllodocidae	
<u>Pelagobia longicirrata</u>	rare; one capture record from Mid Inshore Area
Family Alciopidae	
<u>Torrea candida</u>	common, but never abundant; over a broad area; recorded from Northern Offshore and Southern Inshore Areas.
<u>Naiades cantrainii</u>	high abundances in areas at least 200km from shore; captured throughout the year
<u>Vanadis formosa</u>	common, but never abundant; in areas at least 200km from shore north of 30° N. latitude.
<u>Vanadis crystallina</u>	fairly common, but never abundant; in areas at least 300km from shore
<u>Vanadis minuta</u>	uncommon; distribution similar to that of <u>V. crystallina</u>
<u>Vanadis longissima</u>	less common than <u>V. minuta</u> and overlapping the distribution of <u>V. crystallina</u> and <u>V. minuta</u>
<u>Plotohemia tenuis</u>	common and abundant in cold waters (primarily north of San Francisco); recorded in Southern Offshore and Inshore Areas
<u>Rhynchonerella möbi</u>	uncommon and never abundant; taken at all seasons south of San Francisco at least 400km from shore
Family Tomopteridae	
<u>Tomopteris elegans</u>	common throughout the year; can be extremely abundant, eg. about 400km off the coast between San Francisco and about 30° N. lat.; recorded from Southern Inshore and Offshore Areas
<u>Tomopteris cavallii</u>	uncommon and in low abundance; most common 400-500km from shore
<u>Tomopteris septentrionalis</u>	uncommon and abundant in cold nearshore areas north of San Francisco

Table II-8 (cont.)

Species	Distributional Remarks
Family Typhloscolecidae <u>Typhloscolex mülleri</u>	rare; one record from Southern Inshore Area
<u>Sagitella kowalevskii</u>	uncommon throughout the year; in areas at least 300km from shore south of 34° N. lat.
<u>Travisiopsis lobifera</u>	common throughout the year in cold waters, largely north of 35° N. Lat.

were *Atlanta peroni*, *Atlanta* sp., and larval *Carinaria japonica*.

v. Mollusca - Cephalopoda

Pelagic cephalopods off Southern California have been reported by McGowan (1967) and Young (1972). The records of McGowan for 6 species of larval cephalopods captured at CalCOFI stations during April 1950 and April, June and August 1952 are given in Table II-9. Low abundance levels were recorded. Larval *Abraliopsis* sp. (*Abraliopsis felis*) were captured most frequently off Southern California.

Data for Young's (1972) study (Table 8-7 in Seapy, 1974) were based on 10-ft IKMT tows at various depths. Because the volume of water passing through the net on any given tow was not monitored, Young quantified his data by computing the numbers of animals captured per hour of trawling. Individual station records were combined according to their locations in arbitrary zones (Young, 1972: 3; see Fig. II-34 of this report). In zones 1 and 2, the most numerically-important species were *Abraliopsis felis* and *Gonatus onyx*.

vi. Crustacea - Copepoda

The copepods are one of the most taxonomically difficult taxa in the zooplankton. They are also one of the most abundant and functionally important taxa. CalCOFI records for 69 species of copepods were given by Fleminger (1964, 1967) for April, July, and October of 1958 and for January of 1959. Unfortunately, only 2 stations overlapped the study area off Southern California (Stations 4 and 14 in Fig II-33). The data presented in Table 8-9 in Seapy (1974) serve to indicate the species composition and general abundance levels for the northern-most portion of the study area. Comprehensive data of

Table II-9

PELAGIC CEPHALOPODS OFF SOUTHERN CALIFORNIA
(COMPILED FROM YOUNG, 1972).

THE NUMBER OF INDIVIDUALS CAPTURED PER HOUR OF TRAWLING ARE GIVEN.
THE DATA WERE CORRECTED FOR OBLIQUE CONTAMINANTS TO ESTIMATE
NUMBERS PER HOUR OF TRAWLING AT TRAWL DEPTH. SEE FIG. II-
FOR LOCATIONS OF ZONES 1 THROUGH 5.

	1	2	3	4	5
<u>Abraliopsis felis</u>	1.27	2.20	0.15	0.75	3.43
<u>Bathyteuthis berryi</u>	0.00	*	0.00	0.00	0.00
<u>Chiroteuthis calyx</u>	0.19	0.16	0.26	0.05	0.19
<u>Gaiteuthis phyllura</u>	0.11	0.26	0.28	0.04	0.29
<u>Gonatopsis borealis</u>	0.06	0.40	0.05	0.00	0.21
<u>Gonatus berryi</u>	0.32	0.57	0.59	0.19	0.25
<u>Gonatus californiensis</u>	0.28	0.47	0.16	0.00	0.03
<u>Gonatus onyx</u>	3.12	2.80	1.34	0.05	0.00
<u>Gonatus pyros</u>	0.16	0.24	0.07	0.11	0.03
<u>Grimalditeuthis bomplandii</u>	0.00	*	0.00	0.00	0.00
<u>Helicocranchia pfefferi</u>	0.11	2.28	0.53	0.07	0.04
<u>Histioteuthis dofleini</u>	*	0.00	0.00	0.00	0.00
<u>Histioteuthis heteropsis</u>	0.22	0.52	0.37	0.14	0.18
<u>Japetella heathi</u> (incl. Japetella sp.)	0.09	0.15	0.09	0.25	0.22
<u>Leachia dislocata</u>	0.02	0.07	0.13	0.12	0.31
<u>Mastigoteuthis pyrodes</u>	*	*	0.00	0.00	*
<u>Octopoteuthis deletron</u>	0.24	0.18	0.26	0.05	0.36
<u>Ocythoe tuberculata</u>	0.00	*	0.00	0.00	0.00
<u>Onychoteuthis borealijaponicus</u>	0.05	0.09	0.05	0.00	1.49
<u>Pterygoteuthis gemmata</u>	0.15	0.08	0.30	0.00	0.13
<u>Pyroteuthis addolux</u>	0.00	*	*	0.00	*
<u>Valbyteuthis oligobessa</u>	0.00	*	0.00	*	*
<u>Vampyroteuthis infernalis</u>	0.23	0.57	0.52	0.70	0.89

*low numbers of individuals captured - numbers per hour of trawling not recorded.

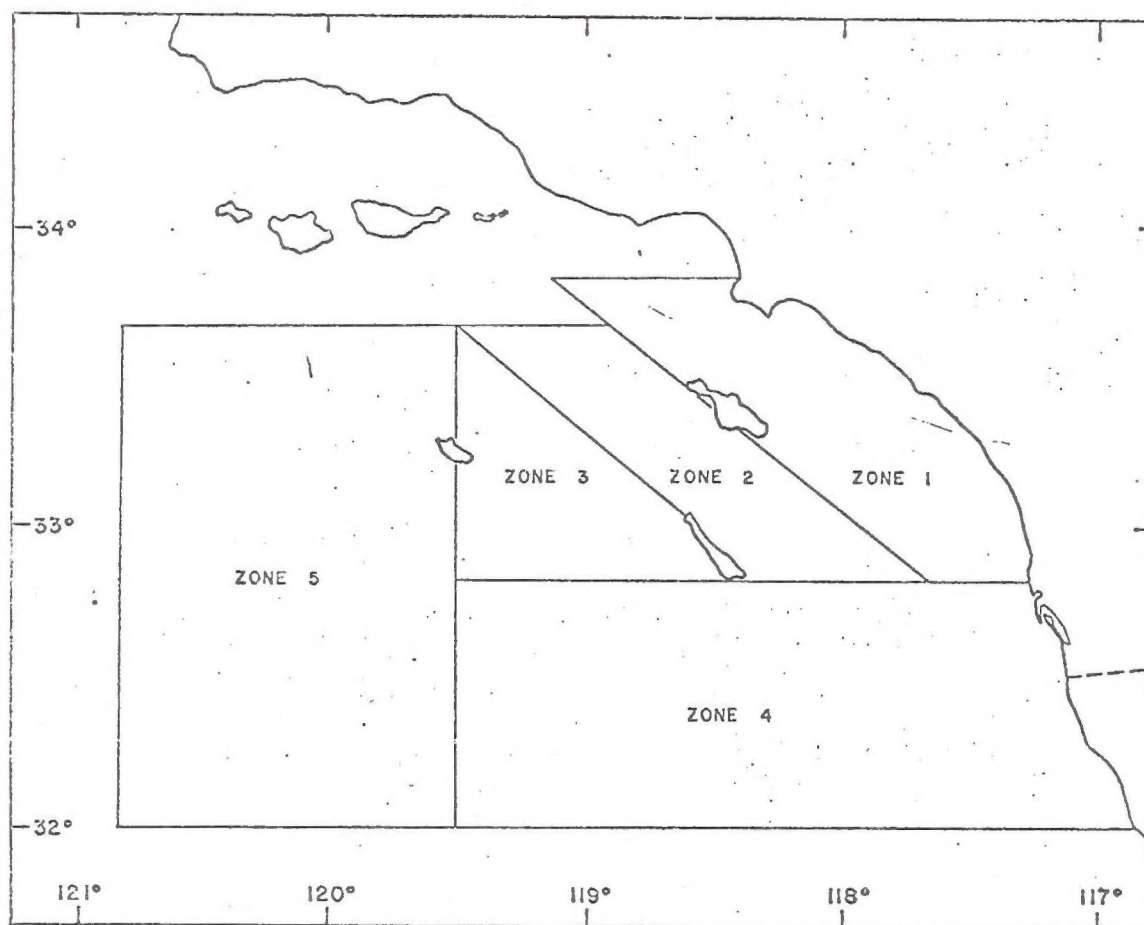


Figure II-34 Locations of 5 zones used by Young (1972) to describe the distributions of cephalopods off Southern California. (figure redrawn from Young 1972)

this nature are largely lacking for the central and southern portions of the study area.

In the Santa Barbara Channel, McGinnis (1971) reported the dominance of surface samples by copepods, principally *Labidocera trispinosa*, which was maximally abundant in November of 1969.

Abundance data for *Acartia tonsa* and *Acartia clausi* (Esterly, 1923) from off the pier at Scripps Institution of Oceanography between September 1916 and August 1918 are given in Table 8-9 of Seapy (1974). High abundance levels of *Calanus helgolandicus* during late May and early June 1970 at six stations off La Jolla (Stations 33 to 38 in Fig. II-33 were reported (Mullin and Brooks, 1972).

The Marine Food Chain Research Group (1968) reported extensive abundance data on naupliar, copepodite and adult stages of *Calanus helgolandicus* and *Rhincalanus nasutus* at three nearshore stations (Stations 55 to 57 Fig. II-33 off La Jolla during April to August of 1967. All stages of *C. helgolandicus* were abundant throughout the sampling period, and were most numerous during mid-late May. Although naupliar stages of *R. nasutus* were collected throughout the sampling period, they were abundant only during late July and early August. Copepodite and adult *R. nasutus* were most common during late May and June.

The copepods reported by Howey (1971) between June 1969 and May 1970 from Anaheim Bay included *Acartia tonsa*, *Paracalanus parvus*, *Labidocera trispinosa*, *Corycaeus* sp., and *Oncaeta minuta*. The most numerically important species was *Paracalanus parvus*.

With the exception of the study in Anaheim Bay by Howey (1971), the cyclopoid copepods off Southern California have been reported only

in an unpublished Ph. D. thesis by Olson (1949). Olson based his studies on 42 stations samples collected from May 10 to July 10 of 1939 during Cruise VIII of the R/V E. W. SCRIPPS off the Pacific Coast between 25° and 45° N Lat. Each sample normally represented a vertical tow from 200 m to the surface, taken with an 0.7-m Nansen Net (0.203-mm mesh). Actual counts of specimens or abundance data were not presented. Ten of the stations were located off Southern California, and the percentage of stations at which each species was captured is summarized in Table II-10. Additional samples were collected from La Jolla Bay and off Scripps pier. Species presence in these samples are given in Table II-10. On the average, cyclopoids constituted 41% of the total copepod population. The most abundant species was *Oithona similis*, which was most numerous in colder northern areas, where it comprised up to 64% of the total copepod population and 90% of the cyclopoid population. At stations off Southern California, *O. similis* represented from 60 to 87% of the cyclopoids present in the samples.

vii. Crustacea - Amphipoda

An account of the pelagic amphipods from the CalCOFI samples for 3 months of 1949 and November of 1950 is given in an unpublished Ph. D. thesis by Bowman (1953). Abundance data at 4 CalCOFI stations were given by Bowman (See Table 8-11 in Seapy, 1974). Recently, Bowman (1973) included data from his thesis in a systematic treatment of the genus *Hyperia* and closely related genera. Where appropriate, synonyms for species names used in Bowman's 1973 paper have been included in parentheses after the species name cited from his thesis records.

TABLE II -10 (continued)

Species	Percentage Occurrence at Stations off Southern California	Presence in Samples		Remarks
		SIO Pier	LaJolla Bay	
<u>Oncaea similis</u>	10		X	
<u>Oncaea subtilis</u>	50	X	X	uncommon, primarily inshore
<u>Oncaea tenella</u>	20	X		
<u>Sapphirina intestinata</u>	0			collected off Catalina Island in March, 1940
<u>Sapphirina nigromaculata</u>	10			
<u>Vetatoria granulosa</u>	30			
<u>Corissa parva</u>	20			
<u>Corycaeus furcifer</u>	0		X	
<u>Corycaeus anglicus</u>	100	X	X	
<u>Corycaeus amazonicus</u>	70	X	X	almost always less abundant than C. anglicus
<u>Farranula curta</u>	0	X	X	collected only from LaJolla and southward

TABLE II-10

RECORDS OF CYCLOPOID COPEPODS IN WATERS OFF SOUTHERN CALIFORNIA
(Compiled from Olson, 1949).

Species	Percentage Occurrence at Stations off Southern California	Presence in Samples		Remarks
		SIO Pier	LaJolla Bay	
<u>Oithona plumifera</u>	40	X	X	widely distributed in warm waters
<u>Oithona spinirostris</u>	90	X	X	
<u>Oithona similis</u>	100	X	X	particularly abundant in cold waters
<u>Oithona oculata</u>	0	X	X	most abundant copepod in Scripps (SIO) Pier samples
<u>Oithona nana</u>	0	X		
<u>Paroithona paryula</u>	80	X		
<u>Oncaea conifera</u>	100	X	X	
<u>Oncaea curta</u>	0		X	
<u>Oncaea dentipes</u>	70			
<u>Oncaea media</u>	40	X		widely distributed, but rare off Southern California
<u>Oncaea mediterranea</u>	20	X	X	
<u>Oncaea minuta</u>	30			

The only other records of pelagic amphipods off Southern California are from a vertical distributional study by Brusca (1967) in waters overlying the Santa Catalina Basin. Horizontal tows at selected depths through the water column (to 1,100 m) were taken with an open 10-ft Isaacs and Kidd midwater trawl. Contamination during the oblique portions of such open net tows effectively limits the usefulness of the resultant samples to indicating the shallowest depth of a species' vertical distribution. A list of the species reported from waters over Santa Catalina Basin by Brusca is given in Table II-11 along with total counts for each species made from one-pint sample aliquots and the shallowest depth at which each species was recorded. *Vibilia armata* was the most numerous species in the aliquot samples.

viii. Crustacea - Cladocera

The Cladocera off Southern California are known from two studies. McGinnis (1971) reported that the most important cladoceran in the Santa Barbara Channel was *Penilia avirostris*, which occurred in high numbers during August, September, and November, and was maximally abundant in December of 1969. Abundances of cladocerans from Anaheim Bay (Stations 51-54 of Fig. II-33) for an 11-month period during 1969-1970 were reported by Slawson (1972). See Table 8-13 in Seapy (1974) for abundance data. The most numerically important species were *Evadne nordmanni* and *Podon polyphemides*.

ix. Crustacea - Euphausiacea

The euphausiids from the CalCOFI samples for selected months between 1954 and 1962 were given by Brinton (1967) and compiled for the Southern California area (Table 8-14 in Seapy, 1974). Brinton

Table II-11
 PELAGIC AMPHIPODS COLLECTED OVER THE SANTA CATALINA BASIN
 (COMPILED FROM BRUSCA, 1967).

Species	Total Number of Individuals Sorted from 1-pint Aliquots	Shallowest Depth at which the Species was Captured(m)	
		Day	Night
<u>Rachotropis natator</u>	77	600	900
<u>Eurythenes obesus</u>	6	685*	
<u>Paracallisoma coecus</u>	56	520	520
<u>Cyphocaris anonyx</u>	115	150*	
<u>Cyphocaris richardi</u>	193	500	500
<u>Platyscelus serratulus</u>	8	170*	
<u>Eupronoe minuta</u>	322	0	0
<u>Primno macropa</u>	315	200	50
<u>Cystisoma fabricii</u>	31	275*	
<u>Cystisoma pellucidum</u>	4	275*	
<u>Calamorphynchus pellucidus</u>	1	360*	
<u>Oxycephalus clausi</u>	2	360*	
<u>Streetsia challengerii</u>	67	200	0
<u>Hyperia spinigera</u>	8	300*	
<u>Hyperia bengalensis</u> (= <u>Lestriginus schizogeneios</u>)**	52	288	85
<u>Hyperia galba</u> (= <u>Hyperia medusarum</u>)**	78	200	85
<u>Vibilia armata</u>	2,742	200	0
<u>Vibilia viatrix</u>	658	0	0
<u>Phronima sedentaria</u>	575	275	80
<u>Paraphronima gracilis</u>	472	80*	
<u>Paraphronima crassipes</u>	922	200	80

*day-night depths not specified - only the most shallow depth is indicated

**identification corrected by Bowman (1973)

selected months for which the number of stations occupied off Southern California were high. *Euphausia pacifica*, *Nematoscelis difficilis*, and *Nyctiphanes simplex* were the numerically important species over the study area. *Stylocheiron longicorne*, *Thysanoessa gregaria*, and *Thysanoessa spinifera* were the next most abundant species.

x. Crustacea - Decapoda

The majority of decapods are not epipelagic and were therefore not analyzed from the CalCOFI samples. Published data on this group off Southern California are limited to a report on replicated oblique tows to a depth of 650 m with a 10-ft IKMT by Atsatt and Seapy (1974). The raw data, on which this paper was based, were used to compile abundance records (Table 8-15 in Seapy, 1974) for San Pedro Basin (Stations 39-41 (day) and 42-44 (night) in Fig. II-33) and Santa Catalina Basin (Stations 45-47 (day) and 48-50 (night) in Fig. II-33). Since abundances of these decapods did not exceed 49 individuals per 1,000 m³, it is not possible to identify the numerically dominant species. From the raw data, however, *Sergestes similis* was shown to be the most numerous species in every sample.

Data on zoea stages of *Callinassa* sp. and *Pinnixa franciscana* from the Anaheim Bay stations (Stations 51-54 in Fig. II-33) were given by Sowby (1973) (Table 8-15 in Seapy, 1974). The early zoea stages were reported in high numbers, irrespective of the time of year.

xi. Thaliacea

Included under the Thaliacea are two groups, the salps and doliolids, which can become numerically dominant in the epipelagic zone. McGinnis (1971) reported that in waters over the Santa Barbara

Channel, the thaliaceans outnumbered the copepods in August of 1969. The doliolid, *Doliolum denticulatum*, was the most abundant species of thaliacean in the samples. High numbers of *D. denticulatum* can occur when they are transported into areas where the water temperature is warm (greater than $14-15^{\circ}$ C) (Berner and Reid, 1961). Surface water temperatures of the inshore areas of Figure II-33 commonly exceed this temperature during summer months and would be a region in which abundant *D. denticulatum* would be expected. The data of Berner and Reid partially support this prediction.

The thaliaceans from the CalCOFI program were reported for 5 months of 1950 and 1951, 4 months of 1952, and two months of 1954 and 1958 (See Table 8-16 in Seapy, 1974) by Berner (1967). The numerically-important species of salps were *Cyclosalpa bakeri*, *Pegea confoederata*, *Salpa fusiformis*, and *Thalia democratica*. The most abundant doliolids were *Dolioletta gegenbauri* and *Doliolum denticulatum*.

c. Distribution of Zooplankton Biomass and Volume

The distribution of zooplankton biomass (in $\text{g}/1,000 \text{ m}^3$) over the CalCOFI sampling area was reported for Spring and Fall cruises of 1955 to 1959 by Isaacs et al. (1969), and for Winter cruises of these same years by Isaacs et al. (1971). Biomass distributions were plotted over the sampling area for the combined taxa and for 17 "functional" taxonomic groupings, including the Amphipoda, Chaetognatha, Cladocera, Copepoda, crustacean larvae, Ctenophora, Decapoda, Euphausiacea, Heteropoda, Larvacea, medusae, Mysidacea, Ostracoda, Pteropoda, Radiolaria, Thaliacea, and Siphonophora.

3. Benthos Including Intertidal Organisms

a. Benthic Algae and Grasses

i. Introduction

The following, with only minor changes, is taken from S.N. Murray (1974c). A discussion of the impacts on this biota may be found in Sections III.C.3. and III.D.2.

The purpose of this chapter is to provide a summation and evaluation of published studies concerned with marine benthic algae and grasses of Southern California, i.e., the offshore waters including the eight Southern California Islands. Literature included in this report has been confined to that collected directly within the area, although attempts have been made to include additional relevant material where appropriate. Priority has been given to published studies deemed most important; therefore, an attempt has not been made to treat all published studies on the topic.

The great majority of the literature discussed has been concerned with macro-algae (Chlorophyta, Phaeophyta and Rhodophyta) and grasses (Spermatophyta) collectively referred to as macrophytes. Relatively little information exists on micro-algal components of the marine benthos, e.g., Cyanophyta (blue-green algae), benthic Bacillariophyta (diatoms) and benthic Chrysophyta (chrysophytes), for the Southern California region as well as worldwide. The contents of this report have been organized under the topics of taxonomy and ecology.

ii. Taxonomy

a) General Floristics

The marine macrophytes from Central California particularly near the Monterey Peninsula, are as well known as for any region of the Pacific Coast of North America (c.f., Smith, 1944;

Hollenberg and Abbott, 1966). Knowledge of the marine macrophyte flora of Southern California however is very much more limited. Most taxonomic studies of Southern California marine macrophytes have appeared in the literature as isolated reports and are mostly studies of morphology and reproduction, descriptions of new species and new distributional records. Most notably, there has been almost a complete absence of floristic studies where the principal aim has been to provide a flora of a specific sight within the Southern California region. Consequently, it is very difficult even today to construct a species list or to depict the structure of macrophyte communities for sights within Southern California.

Much of the knowledge of the algal flora of Southern California has been restricted to the mainland and gained from the works of W.A. Setchell (1912, 1914a, 1914b), N.L. Gardner (1913, 1917, 1926, 1927a, 1927b, 1927c, 1927d, 1927e, 1927f, 1940), Setchell and Gardner (1920, 1924, 1925, 1933), H. Kylin (1941), G. J. Hollenberg (1943, 1944, 1945, 1948, 1958, 1970, 1971), E.Y. Dawson (1941, 1946, 1949, 1950, 1952, 1954, 1957, 1958, 1960, 1961a, 1961b, 1962, 1963a, 1963b, 1966), and Dawson, Neushul and W.D. Wildman (1960). Currently, a very much needed compilation, *The Marine Algae of California* (Abbott and Hollenberg, in preparation), is in the final stages of preparation. This work will provide a much needed assimilation of taxonomic information of California algae including the algal flora of Southern California and will be highly important in that it will represent a common "baseline" for further taxonomic study.

Table 9-1 in Murray (1974c) provides a list of macrophyte species reported in Southern California including the eight Southern California

Islands. This list has been prepared by the author with considerable assistance from Dr. Isabella Abbott (Hopkins Marine Station of Stanford University) and Dr. Thomas Widdowson (California State University, Long Beach).

b) Floristic Assemblages

As previously indicated, relatively little information exists with regard to floristic assemblages of Southern California. The most important works of this nature have been compiled for a few areas on the Southern California mainland (Dawson, 1945, 1959, 1965, 1966; Nicholson and Cimberg, 1971; Widdowson, 1971), certain of the Southern California Islands (Dawson, 1949; Dawson and Neushul, 1966; Neushul, Clarke and Brown, 1967; Nicholson and Cimberg, 1971; Sims, 1974) and for kelp beds (Dawson, Neushul and Wildman, 1960; North, 1971). Table II-12 presents a compilation of the most common algal species of Southern California taken from Dawson (1959) and Table E3-1 (Appendix 10, Section E.3.) provides a list of seaweeds associated with Southern California kelp beds published by North (1971).

c) Southern California Islands

The eight Southern California Islands have been treated (Philbrick, 1967) as two groups, the Northern Channel Islands, consisting of San Miguel, Santa Rosa, Santa Cruz and Anacapa and the Southern Channel Islands including Santa Barbara, San Nicolas, Santa Catalina and San Clemente. These islands contain the only truly "pristine" marine communities that remain in the Southern California region. Additionally, the biota of the islands is extremely

Table II-12. List of the 46 Most Common Marine Plants of Southern California in Order of Relative Frequency.
From: Dawson (1959)

Corallina vancouveriensis
Egregia laevigata
Gigartina canaliculata
Phyllospadix spp.
Gigartina leptrohynchos
Gastroclonium coulteri
Bossiella gardneri- *dichotoma* complex
Pterosiphonia dendroidea
Gelidium coulteri
Rhodoglossum affine
Gigartina spinosa
Chondria nidifica
Plocamium pacificum
Gelidium robustum
Smithora naiadum
Pelvetia fastigiata
Pterocladia capillacea
Ulva californica
Corallina officinalis v. *chilensis*
Chaetomorpha aerea
Centroceras clavulatum
Prionitis lanceolatoata
Porphyra perforata
Lithothrix aspergillum
Melobesia mediocris
Enteromorpha compressa
Gracilariopsis sjoestedtii
Gelidium purpurascens
Laurencia pacifica
Pachydictyon coriaceum
Gymnogongrus leptophyllus
Ceramium eatonianum
Chondria decipiens
Gracilariopsis andersonii
Gigartina volans
Gelidium crinale v. *luxurians*
Nienburgia andersoniana
Gracilaria cunninghamii
Eisenia arborea
Cryptopleura violacea
Spermothamnion snyderae
Polysiphonia collinsii
Pterosiphonia baileyi
Hildenbrandia prototypus
Jania natalensis
Rhodomenia palmettiformis

important to the understanding of the biogeography of the Pacific Coast of North America in that their location is along a major break in the marine environment at Point Conception. Presumably because of their relative inaccessibility, however, these islands have received remarkably little scientific attention.

The benthic algae and marine grasses of the California Islands have not been adequately described. Dawson (1949) emphasized this point when he noted how remarkable it was that a total of fewer than 20 species of algae had been reported from Southern California Islands prior to his work. Dawson indicated that one hundred and ninety-seven species of benthic algae had been identified but reported on only the undescribed species and some of the more outstanding of his new records. Much of the floristic study has never appeared in the literature although some reports are included as range extensions in Dawson's works on (1952, 1954, 1960, 1961, 1962, 1963a, 1963b) the marine red algae of Pacific Mexico. Subsequently, additional information on the algal floras of these islands has been limited to collections of macrophytes from Anacapa Island (Dawson and Neushul, 1966; Clarke and Brown, 1967), San Clemente Island (Sims, 1974), and limited lists (Nicholson and Cimberg, 1971) of Macrophytes from all but San Miguel Island. Several scattered reports (Silva, 1951, 1957; Chapman, 1961; Caplan and Boolootian, 1967; Foster, 1972) have provided little additional information on the macrophyte flora of the Islands.

iii. Ecology

a) General Information

Studies of the ecology of communities of benthic macrophytes performed in the Southern California region are surprisingly few in number. Few studies have been performed on intertidal macrophytes; however, the algal communities of the nearshore benthos, particularly those associated with the giant kelp beds, have received considerable attention.

b) Intertidal Ecology

1) Southern California Mainland

Sandy beaches have their complement of vegetation in the form of kelp and other algae and plankton washed ashore in addition to bottom microscopic plants (mostly diatoms) living within the spaces between sand grains. Although the majority of the mainland shores consist of sandy beaches, these floral assemblages are more transient, and far less studied than the rocky shore flora.

Ecological studies of intertidal communities of Southern California are remarkably few in number. Of the limited information available, the most useful appears to be that concerned with communities of macrophytes (Dawson, 1959, 1960; Widdowson, 1971; Nicholson and Cimberg, 1971). Dawson (1959; 1965) surveyed a number of rocky intertidal stations in Southern California from 1956-1959 in an attempt to construct records of the distribution and abundance of the more conspicuous macroscopic algae. His efforts were part of a California State Water Pollution Control Board project, initiated in 1954, concerned with methods and effects of the disposal of sewage into the sea.

Prior to Dawson's studies, the only useable information for comparisons was contained in the collections of intertidal algae gathered between 1895 and 1912 by W.A. Setchell and N.L. Gardner from three rocky areas (Whites Point, Sunset Blvd. Beach, and Pt. Fermin) in Los Angeles County. After examining these collections, Dawson (1959) concluded that approximately a 50-70% reduction in the number of species comprising the algal floras at the Whites Point and Sunset Blvd. sites had occurred, whereas little change was evident at Pt. Fermin. In that the Whites Point and Sunset Blvd. stations were subject to a high degree of sewage pollution, Dawson attributed the observed declines to sewage effects. Further, Dawson (1959) reported that several species of articulated coralline algae were capable of remarkable development within close proximity to marine sewage outfalls.

To expand on Murray's summary of Dawson's study, the Allan Hancock Foundation (1965) summarized some seasonal and vertical observations of the intertidal flora. It was apparent that there were marked seasonal changes in the composition of the flora, more so in some areas than in others. The maturity of certain dominant species may, at some seasons, completely change the appearance of the flora. In other instances, seasonal changes in the sand deposits of an area may markedly affect the flora by altering the substrate, sometimes by the complete burial of the algal inhabitants of the rock outcrops for several months. The annual cycles, however, are subject to great variation from year to year, and in a given area the local ecological variables may partly or largely overrule the general annual cycle.

Accordingly, in making seasonal observations over a period of a few years at a large number of localities, one is impressed almost as much by the annual variations as the seasonal ones.

Nevertheless, comparisons of the seasonal observations at 39 stations visited twice or more permits the following generalities to be made: 1) In gross aspect the Southern California benthic algae does not show conspicuous seasonal differences in quantity or quality. Most of the larger dominant species are present throughout the year, although the luxuriance, age and condition of the plants may show considerable seasonal variation. 2) It is in the upper levels of the intertidal region, partly subject to shifting sand, that marked seasonal growth and decline of colonies of annual plants, such as *Enteromorpha*, *Ulva*, *Porphyra*, *Chaetomorpha*, etc., are commonly noted. 3) In the lower intertidal and infratidal areas, seasonal variation in composition of the flora is confined largely to species which are not large members of the flora. Thus, a number of annual species may appear during the spring and summer, augmenting the principal vegetation which remains throughout the year. 4) At most stations, the flora as a whole shows a decline in growth and luxuriance during the summer and fall. Most annual species reach their peaks in summer or early fall, and a few annuals mature in winter or spring.

At the lower levels of the intertidal zone which are uncovered only occasionally or not at all, attached algae tends to become more profuse and according to Ricketts et al., (1968) the large kelp *Laminaria* and the seed plant *Phyllospadix* (eel grass) become the most dominant

forms. In an attempt to describe changes in the algal composition of the Southern California intertidal, Widdowson (1971) surveyed several of Dawson's original stations. Widdowson's study revealed a general and widespread decline in the marine intertidal flora near Los Angeles since 1956-1959. Sewage pollution was also implicated although the degree to which a station was exposed to human traffic was reported to be more highly correlated with floral decline.

Subsequent to the 1969 Santa Barbara Oil Spills, several studies (e.g., Straughn, 1971; Foster, Zingmark and Neushul, 1970) were initiated to determine the effects of oil on marine populations. Nicholson and Cimberg (1971) surveyed 10 Southern California stations (8 corresponded to those of Dawson) in an attempt to evaluate the effects of oil on rocky intertidal populations. The results of their studies supported the conclusions of Widdowson (1971) in that a reduction in the variety of species in the Southern California intertidal algal flora had occurred. Comparisons between patterns of species distribution also revealed (Nicholson and Cimberg, 1971) that certain green algae, characteristic of environments rich in organic chemicals were more abundant in 1969-70 than in 1956-59. The presence of systems for the uptake of amino acids in *Ulva*, *Corallina* and *Gelidium*, all of which have been reported (Nicholson and Cimberg, 1971; Widdowson, 1971) to be abundant in Southern California, have been demonstrated and implicated (Stephens and North, 1972) in the success of these algae in sewage-polluted environments.

2) Southern California Islands

Ecological work on intertidal communities of the Southern California Islands has been limited to studies of San Nicolas (Caplan and Boolootian, 1967), Santa Cruz (Hewatt, 1946) and San Clemente (Murray and Littler, 1974a). The biota of each of these islands is somewhat different (Neushul, Clarke and Brown, 1967) with San Nicolas being strongly influenced by the cold California current whereas Santa Cruz receives both cold water from the California current and warmer water from the south; San Clemente Island is bathed primarily by warmer southern waters.

Caplan and Boolootian performed a study of the littoral ecology of 2 rocky areas on San Nicolas Island in June of 1964. Their report included contributions of only 19 macrophyte species and omitted a goodly portion of the intertidal region (+2.0 ft). Conclusions of this study revealed that the flora and fauna of the intertidal region were representative of both northern and southern California associations and that the dominant species in each intertidal zone were also similar to mainland species.

In the summer of 1939, W.G. Hewatt stayed on Santa Cruz Island, and established species lists for Scorpion Harbor, Smuggler's Cove, Pelican Bay, Prisoner's Harbor, Christy Harbor and Wellis Harbor. These collections however, included only faunistic components and, other than for a few passing remarks, species of macrophytes were omitted.

Studies by Murray and Littler (1974a) have been carried out since June 1971 on marine intertidal communities of Wilson Cove, San Clemente Island. These studies have involved general floristics,

analyses of standing stock and primary productivity of communities under the influence of sewage stress from the local U.S. Navy base and of nearby control regions.

The low volume sewage discharge (20-25,000 gal/day) altered (Murray and Littler, 1974b) species composition and reduced spatial heterogeneity and species diversity of macrophyte-dominated intertidal communities on leeward San Clemente Island, California. A total of 13 species, which provided 91.7% cover, were recorded for the sewage-affected area while 30 species and 100% cover occurred in neighboring control areas. The brown algae, *Egregia laevigata*, *Halidrys dioica* and *Sargassum agardhianum*, the angiosperm *Phyllospadix torreyi* and the crustose coralline *Lithophyllum decipiens* were conspicuously absent from the outfall region; these species contributed approximately 35% of the cover of control area intertidal communities. Cover of blue-green algae, *Ulva californica*, *Gelidium pusillum* and *Pterocladia capillacea* was significantly enhanced in the outfall area while that of *Gigartina canaliculata* decreased. A great reduction in stratification and hence spatial heterogeneity, primarily due to the absence of large brown algae and *P. torreyi*, occurred in the sewage-affected area, where a low turf consisting of blue-green algae, *U. californica*, *G. pusillum* and small plants of *P. capillacea* was found in similar tidal intervals. Simple species counts and four different quantitative indices revealed that the diversity of control area communities was considerably greater than that of the outfall region.

The total primary productivity of the intertidal macrophyte

community under sewage stress ($127.1 \text{ mg C/m}^2 \text{ per hr}$) was not (Littler and Murray, 1974) significantly different from that of nearby control (non-polluted) communities ($125.4 \text{ mg C/m}^2 \text{ per hr}$) even though there was 8% less cover and about half as many species near the outfall plume. The intertidal macrophytes on leeward San Clemente Island, California, produce approximately $485 \text{ net g C/m}^2 \text{ per year}$, a rate comparable to that reported for most marine communities. No apparent relationship was revealed between the productivity of an alga and the division to which it belongs; however, productivity was associated with growth form. Encrusting prostrate forms were the lowest producers in terms of $\text{g C/m}^2 \text{ per hr}$ and $\text{g C/g dry wt per hr}$; sheet-like and finely-branched forms showed a greater productivity than coarsely-branched forms. *Gelidium pusillum* and *Ulva californica*, associated with the disturbed outfall area, show considerably greater productivity per unit of thallus area than any of the other algae measured.

Obviously there is risk in extrapolating short term productivity rates to daily or yearly rates.

c) Subtidal Ecology

1) Southern California Mainland

The majority of literature on the ecology of subtidal macrophyte communities has been gathered on kelp bed communities. The dominant plant comprising Southern California kelp beds is *macrocystis pyrifera*. Along the inward border of a typical Southern California kelp bed, *Egregia* becomes dominant whereas at the outer edge, *Pelagophycus* becomes the most conspicuous plant. Surf grass (*Phyllospadix*) and several medium sized brown algae (*Eisenia*, *Pterygophora*, *Laminaria*, and *Desmarestia*) occur from the intertidal to

almost the outer fringes of the large floating kelps, especially in areas of clear water.

Beneath these forms, a number of smaller green, brown, and red algae become common. The marine flora associated with kelp beds is fairly well known. North (1971) has compiled a list of the plants associated with Southern California and Northern Baja California kelps (Table II-17, Appendix 10, Section E.3). This table was compiled from personal observations by North and works by Smith (1944); Limbaugh (1955), Turner et al. (1964 a, b, 1965); McClean (1962) and Dawson, Neushul and Wildman(1960).

Macrocystis is distributed (North, 1972) in boreal and temperate waters near every major land mass in the southern hemisphere and along the Pacific coast of North America from Alaska to Punta San Hipolito in Central Baja California. North (1971) has hypothesized that the world wide distribution of the genus is limited by temperature since Macrocystis is absent from the tropics. Three species of Macrocystis have been listed from California waters, M. integrifolia Bory, M. pyrifera (Linnaeus) Agardh and M. angustifolia Bory (Womersley) (North 1971). The morphology and physiology of plants is highly variable; Macrocystis pyrifera from Southern California, for example, does poorly at temperatures exceeding 20°C whereas 600 Km south, populations of M. pyrifera flourish in water that reaches 26°C in later summer (North, 1957). capabilities of the two Macrocystis populations also differ (Clendenning, 1958). Clendenning (1971) has reported an annual organic production for a "good" kelp bed of 6.50 to 6.65 tons per acre-year. Figure II-35 depicts the kelp beds of Southern California, showing numerical designation assigned by the California Department of Fish

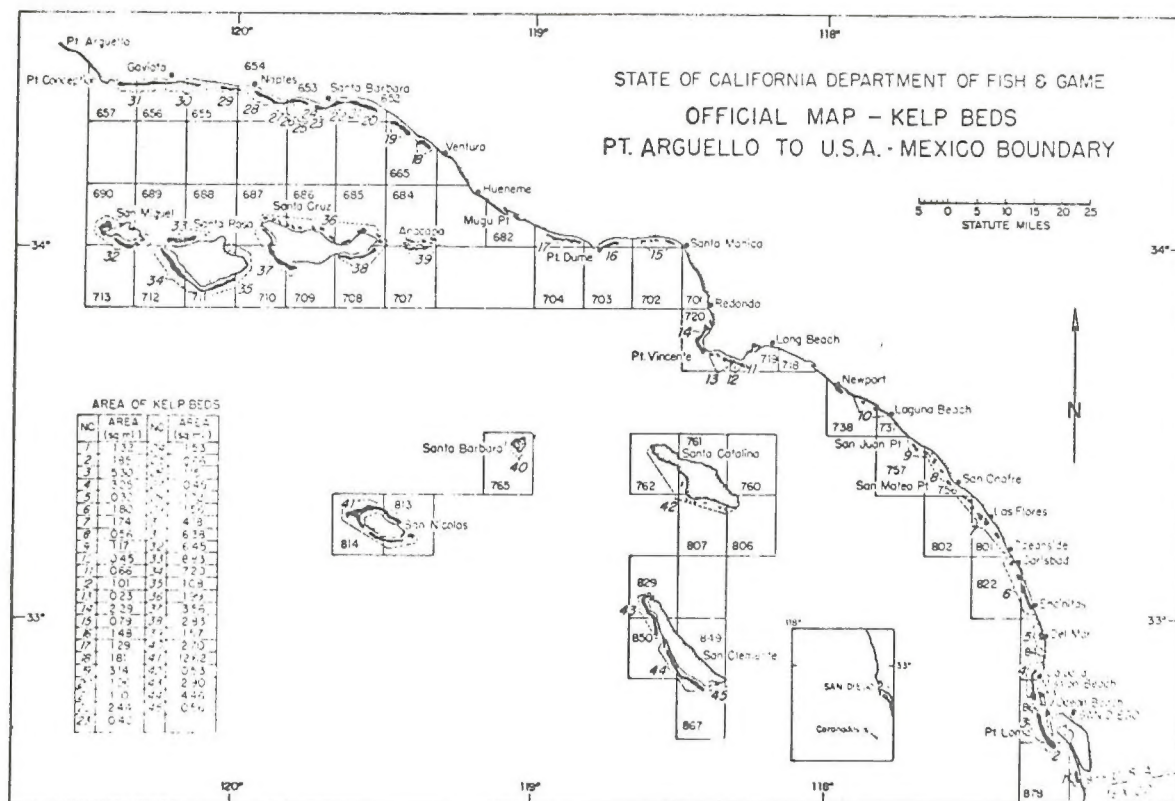


Figure II-35 Official map of the numbered kelp beds in Southern California, and selected statistical areas, 10' lat. x 10' long. used for reporting fish catches.

From: North and Hubbs (1968)

and Game (see also Graphic #5 of this E.I.S.).

2) Southern California Islands

The subtidal ecology of the California Islands has been poorly studied. Studies of subtidal plant and animal communities of Anacapa Island (Neushul, Clarke, and Brown 1967) have helped portray the distribution of dominant plant and animal species in nearshore kelp beds and provided information on the biogeographical status of plant and animal species. The stress of currents applied to large plants was discussed; later work on *Eisenia* (Charters, *et al.*, 1972) being a follow-up to these observations. Algal turf constituents of the nests of *Hypsypops rubicunda*, the ocean goldfish have been described for populations at Coches Prietos, Santa Cruz Island. The University of Southern California Allan Hancock Foundation has conducted a systematic survey of the marine biota of Santa Catalina Island in conjunction with the marine laboratory there. These surveys are in progress and should provide additional information on nearshore ecology.

3) Kelp-bed Research Programs

Since the early 1950's, the kelp beds of Southern California have received a great deal of scientific attention. North (1968) has described the historical development of much of these efforts prior to 1968. These can be summarized (largely after North, 1968) as follows:

During the early part of the 1950's the dwindling kelp beds of the Southern California region attracted much general concern. Causes

for the general, well-documented reduction of beds could only be speculated, however, detrimental effects of harvesting activities and pollution were most frequently discussed. These matters came to the attention the the California State Legislature and the State Department of Fish and Game. A State Kelp Study Committee was subsequently formed to advise the California Fish and Game Commission. The committee concluded that much basic biological knowledge was necessary before any proper decisions could be made and recommended a large scale research program on kelp to be undertaken.

The Kelp Investigations Program was established as an outgrowth of this recommendation and received funds from the Department of Fish and Game, the State Water Quality Control Board and the National Science Foundation for pursuing kelp studies.

These research efforts became known as the IMR Kelp Program and lasted from 1956 to 1963 during which a number of progress reports and three large publications *An Investigation of the Effects of Discharged Wastes on Kelp* (State Water Quality Control Board, 1964); *Utilization of Kelp-Bed Resources in Southern California* (North and Hubbs, 1968) and *The Biology of Giant Kelp Beds (Macrocystis) in California* (North, 1971) resulted.

One of the principal findings of the IMR program was that excessive grazing by large populations of sea urchins were destroying the remains of several important Southern California Kelp Beds. A second project, The "Kelp Habitat Improvement Project" was first funded in 1962 to determine if these urchin populations could be controlled. This

project is yet active and has expanded geographically from San Diego to Orange and Los Angeles Counties. It has been supported since its inception by grants from the Kelco Company of San Diego (a Kelp Harvesting concern). Additional monies have been received from the Fish and Game Commissions of San Diego, Orange and Los Angeles Counties (since 1965 and 1966), Ocean Labs, Inc., of Irvine, Ca. (since 1969), Office of Sea Grants, U.S. Department of Commerce (1968, 1970, 1972), Los Angeles Rod and Reel Club Foundation (1970) and the Balboa Angling Club (1972). The Kelp Habitat Improvement project began at the Institute of Marine Resources and has continued at the California Institute of Technology since 1964. Dr. Wheeler J. North has been the principle investigator since the projects inception and much of its success can certainly be attributable to his energies and excellent direction.

The following summaries of the Kelp Habitat Improvement Project have been given in a recent annual report (1971-72).

San Diego County: The project began operations in San Diego County in September of 1962 with initial work being directed towards the control of urchin populations with quicklime off Pt. Loma. Lesser efforts were made to restore kelp beds at La Jolla and barren Imperial Beach. The principal factor found to hinder *Macrocystis* expansion at Pt. Loma was grazing by sea urchins. Through programs directed at urchin control the Pt. Loma beds were restored to 50% of their maximum area by 1967.

The La Jolla kelp beds received increased attention after 1967.

Grazing pressure from urchins and the occupancy of bottom territory by other smaller kelps were viewed as the factors preventing the establishment of *Macrocystis*. Programs of urchin monitoring and control and the dispersal of cultures of embryonic *Macrocystis* succeeded in restoring approximately 10% of the former maximum kelp coverage. In 1963, 1965-67 small colonies of *Macrocystis* were established from transplants in the Imperial Beach region. These, however, were overrun by urchins. In 1970, the Imperial Beach Kelp restoration activities were accorded top priority. Urchin monitoring and clearing activities and the dispersal of embryonic and juvenile sporophyte plants of *Macrocystis* have been carried out. Through these efforts 200 attached and transplanted plants, some 10-20 feet high, composed the Imperial Beach kelp stand by the end of June, 1972.

Orange County: The program in Orange County has consisted of transplantation of adult *Macrocystis*, dispersal of cultures of embryonic sporophytes and the control of populations of sea urchins. Initial operations, begun in 1967, were to restore kelp within 5 miles of coast between Laguna Beach and Corona del Mar. These efforts have been highly successful as indicated by the fact that the Laguna-Corona del Mar Kelp beds represent the only beds within the county that have shown a trend other than general deterioration during the past 14 years. *Macrocystis* stands now occur almost continuously in the area although many of the plants are young and have yet to produce a surface canopy. The large kelp beds that occurred from Dana Point south to San Mateo Point were once the largest in the county. These have been reduced drastically and now consist of only small wellspread patches. Kelp

restoration activities were initiated off Dana Point in 1972.

Los Angeles County: The fifth year of kelp bed restoration activities in Los Angeles County was completed in 1971-72; these operations have been directed towards the Palos Verdes coastline where thirty years previously, extensive beds ringed the entire peninsula. Activities have included the transplantation of kelps from Southern California beds to Abalone Point and Whites Point on the Palos Verdes peninsula, introduction of cultured juvenile sporophytes, dispersals of cultured embryos, urchin monitoring and control, and control programs for grazing fishes. As of 1972, a relatively small crop of plants (50 adult transplants and 50 juveniles plus several dozen younger plants) has been protected at Abalone Cove, the site of most efforts.

In 1970, members of the Ocean Fish Protective Association conceived a plan for enhancing the Palos Verdes nearshore in addition to work being performed as part of the Kelp Habitat Improvement Project. This work involved efforts at controlling the dense populations of urchins occurring along the Palos Verdes peninsula. The aid of amateur divers of Los Angeles was solicited in this regard. In August of 1971, 700 amateur divers armed with hammers, etc., spent the day reducing the urchin populations at Whites Point in water 20-30 feet deep. In the ensuing months, growth of algae appeared in areas where urchin populations had been decimated; subsequent operations have attempted to further the aim of reducing urchin populations and thereby created areas for seaweed development.

It is quite clear that the "kelp projects" have received a high degree of priority from Federal, State and Local agencies. Much work and the expenditure of large sums of money has occurred in attempts to understand and prevent kelp bed deterioration. These programs have been surprisingly successful and have gathered some of the best information available worldwide on the *in-situ* ecology of the large kelps.

The reader is referred to Section II.G.5. of this Environmental Impact Statement for a discussion of the benthic algae and grasses, including the kelp beds, as Economic Resources in Southern California.

b. Benthic Invertebrates

The following section was taken primarily from a report prepared by Donald B. Bright of the Southern California Ocean Studies Consortium (1974). Subjects not taken from Bright's report were Rocky Intertidal, Subtidal Hard Bottom, Mainland Shelf, and the Introduction to Waste-water Discharges. Unless otherwise indicated, all figures and tables are taken from Bright (1974).

i. Introduction

The benthic (bottom) organisms are important members of the marine ecological system. They affect and are affected by the distribution of chemicals and materials in the sediments. They are subject to fallout of materials added to or generated in the overlying waters, and they may concentrate chemicals and materials in their environment, in some cases, transforming these substances into innocuous or more toxic forms. Many of the benthic organisms are planktonic or freeswimming at some stage in their life cycles and, in this form, are a food source for other biota; most are also a food source in their adult stages. Thus, their importance lies in (1) their position in the marine food web and their role in the concentration and food-web transfer of contaminants, especially to other members of the food web and to man, (2) their vulnerability to environmental stress, (3) their usefulness as indicators of past and current environmental conditions, (Southern California Coastal Water Research Project - SCCWRP, 1973).

The web of organisms found along the Southern California coast is extensive. Numerous benthic invertebrate species show a wide distribution while some are abundant but occur only in selected geographical

areas. We have made an attempt to review major papers, and to include accounts for all major groups of benthic invertebrates.

This account is divided into three major sections:

- A. Species lists of major groups of benthic invertebrates.
- B. Major benthic invertebrate communities.
- C. Environmental impact on benthic invertebrates, Southern California Borderland.

ii. Benthic Invertebrates

This section of Bright's paper includes three lists:

- A. Groups of marine benthic invertebrates found in Southern California.
- B. Range and habitats of benthic marine mollusks.
- C. Species list of major benthic invertebrates of California Borderland.

The lists are by no means exhaustive. However, all major groups have been considered. Small groups known to be present, but not covered in this account are: Gastrotricha, Kinorhyncha, Nematomorpha, Pogonophora and Tardigrada.

Table II-13. Groups of Marine Invertebrates Found in Southern California.

This list is modified from that presented by Fay (1972). The list is not complete; it is included to provide an overview for consideration of the general diversity of primarily benthic invertebrates found in Southern California. Not all species are strictly benthic, at least during their entire life cycle. For a list of Molluscan Genera with general comments on depth and habitat, and a species list of Major Benthic Invertebrates of California Borderland, see Tables 10-23 and 10-24 in Bright (1974).

Table II-13 (Continued)

Group	Habitat	Importance	Number of Species
ENTOPROCTA	Spreading colony on rock, shell or worn tubes	Feed on plankton; eaten by carnivorous grazers	1
PHORONIDEA	On rocks, on solid objects, in sediments, on floats.	Feed on plankton; eaten by carnivorous grazers	7 est.
BRACHIOPODA	On rocks or in sediments	Feed on plankton; eaten by fish, starfish	4
ASCHELMINTHES: NEMATODA (Round worms)	Anywhere	Free living, parasitic; feed on detritus or intestinal contents	
ANNELIDA: POLYCHAETA (Segmented worms)	On rocks, shells, solid objects, in sediments; in tubes or free living	Feed on plankton, detritus, other worms, other organisms; eaten by fish, crabs, starfish, snails	594
OLIGOCHAETA (Earth worms)	In sediments, under rocks, among shells	Feed on detritus; fed upon by fish, crabs, snails, starfish	20 est.
ARTHROPODA: PYCNOGONIDA (Sea spiders)	Free living; parasitic on Coelenterates	Feed on body fluids of host	8
ARACHNIDA (Sea spiders pseudoscorpions)	Free living among sand grains and in rocky tidepools; pseudoscorpions live in high intertidal zone	Feed on detritus	5 est.

Table II-13 (Continued)

Group	Habitat	Importance	Number of Species
CRUSTACEA (Fairy shrimp, cladocerans, ostracods, copepods)	Everywhere; commensal, planktonic, parasitic; in sediments, in tidepools	Graze on phytoplankton or detritus; some are commensal, feeding on organic matter associated with host; parasitic forms feed on body fluids of host; planktonic copepods are important food for fishes which graze on zooplankton	1,000 est.
CIRRIPEDIA (Barnacles)	Free living, sessile forms on any solid surface; some parasitic on crabs, sea fans, whales	Feed on plankton, detritus; parasitic forms absorb body fluids of host or irritate or interfere with host	10
MALACOSTRACA: PERICARIDA: Mysidacea	Free living among kelp, on sandy bottoms, among fouling organisms in bays	Mysid shrimp graze on phytoplankton; important as fish food.	5 est.
Cumacea	Free living on sandy bottoms	Feed on plankton and detritus; fed upon by fishes	7
Tanaidacea	Lives among mussels and rocks in littoral zone.	Feeds on plankton	5 est.

Table II-13

GROUPS OF MARINE INVERTEBRATES FOUND
IN SOUTHERN CALIFORNIA
(Modified from Fay, 1972)

<u>Group</u>	<u>Habitat</u>	<u>Importance</u>	<u>Number of Species</u>
PORIFERA (Sponges)	Attached to rocks, solid objects, boring in shells, on mud flats.	Feed on plankton and are fed upon by specialized organisms such as nudibranchs.	79
CNIDARIA (Anemones, corals, seafans, sea pansies, jellyfish, etc.)	Attached on rocks, on solid surfaces; on sedimentary bottoms; attached to other organisms, planktonic.	Mainly feed on plankton; serve as food for specialized organisms; jellyfish are a nuisance to swimmers.	130
PLATYHELMINTHES (Flatworms)	Free living among rocks, shells; parasitic.	Feed on detritus incidentally eaten by fish, birds; parasitic forms ingest flesh of host.	40
NEMERTEA (Ribbon worms)	Among rocks and shells sedimentary bottoms	Predatory on other worms: no known predators.	54
SIPUNCULA	Among rocks and shells, sedimentary bottoms	Feed on plankton and detritus; eaten by crabs, fish, octopuses, starfish.	12
ECTOPROCTA (Moss animals)	Encrusting on rocks, shells, or algae or bushy growths or calcareous colonies	Feed on plankton and detritus; fed upon by carnivorous grazers and specialized predators.	212

Table II-13 (Continued)

Group	Habitat	Importance	Number of Species
Isopoda (Pill bugs)	Free living in all zones and habitats; some parasitic; some bore in wood	Feed on plankton, detritus, scavenge body fluids of host; fed upon by crabs, fish; destroy wooden structures in ocean	106
Amphipoda (Beach hoppers, sand fleas)	Everywhere; free living, in tubes, parasitic	Feed on plankton, detritus scavenge body fluids of host; fed upon by crabs, snails, fish	119
Natantia (Shrimps, prawns) Reptantia (Lobster, mud shrimp) Anomura (Hermit crabs, porcelain crabs, mole crabs) Brachyura (Crabs)	Everywhere; free living, in burrows, among rocks, on sand, among sea weeds; some commensal	Feed on plankton, detritus, worms, snails; fed upon by crabs, fish, humans	198
Stomatopoda (Mantis shrimp)	In burrows on sandy bottoms or among rocks	Feed on fish, worms, clams, shrimp; eaten by fish	3
MOLLUSCA: AMPHINEURA (Chitons)	On rocks or other solid surfaces	Feed on films of algae, on algae, and on detritus	19
GASTROPODS (Snails)	Everywhere	Feed on algae, specific animals, worms, clams, parasitic	260

Table II-13 (Continued)

Group	Habitat	Importance	Number of Species
ECHINOIDEA (Sea urchins, sand dollars)	Everywhere; on sand, in sand, on rocks, on algae	Feed on algae, plankton, ecto- procts, whatever they can capture or find as scavengers; fed upon by starfish and one another; no parasitic forms	10
CRINOIDEA (Sea lillies)	On rocks	Feed on plank- ton; no parasitic forms	1
ECHIURA	In sediments	Feed on plank- ton and detritus; one with several commensals	3
POGONOPHORA	In sediments	Feed on detritus, No est. plankton	
CHORDATA: UROCHORDATA (Sea squirts, salps)	Everywhere; on sand, on rocks, under rocks, on algae, on floats	Feed on plank- ton; fed upon by fish and star- fish, some snails	39

Table II-13 (Continued)

Group	Habitat	Importance	Number of Species
PELECYPODA (Clams, mussels)	On rocks, in sediment, under rocks, boring in rocks and wood, parasitic, commensal	Feed on plankton; may bore in wood; fed upon by starfish, crabs, lobster, fish, rays, octopus; interfere with movement or bore into shell of host	379
CEPHALOPODA (Octopus squid)	Concealed under rocks or solid objects, on sand bottoms, pelagic	Feed on fish, clams, worms, snails; fed upon by fish, humans, pinnipeds, cetaceans; squid may be present in enormous numbers.	8
SCAPHOPODA	In sediment	Feed on plankton and detritus	1
ECHINODERMATA: OPHIODERMA (Brittle starfish)	Everywhere; on sand, among rocks and algae, under rocks	Feed on plankton, detritus, or on small animals; fed upon by fish, starfish; no parasitic forms	23
ASTEROIDEA (Starfish)	Everywhere; on sand, on rocks, sea weeds, under rocks	Feed on clams, mussels, worms, detritus; some cannibalism and predation within class; no parasitic forms	19
HOLOTHURIODEA (Cucumbers)	Everywhere; in sand, on sand, in crevices, among rocks, algae	Feed on plankton, detritus; no known enemies save for non-specific predation by starfish	34

Table II-14 Common Conspicuous and Characteristic Intertidal Animals of
Southern California Rocky Shores (Hedgpeth and Hinton, 1961)

Zone 1: Splash zone

Rock louse	<i>Ligia occidentalis</i>
Gray Littorine (Periwinkle)	<i>Littorina planaxis</i>
Checkered Littorine	<i>Littorina scutulata</i>
Acorn barnacle	<i>Balanus glandula</i>
Acorn barnacle	<i>Cthalamus fissus</i>
Rough limpet	<i>Acmaea scabra</i>
Finger limpet	<i>A. digitalis</i>
File limpet	<i>A. limatula</i>
Tide pool copepod	<i>Tigriopus californicus</i>

Zone 2: High tide zone

Checkered Littorine	<i>Littorina scutulata</i>
Black turban	<i>Tegula funebris</i>
Speckled limpet	<i>Acmaea persona</i>
Owl limpet	<i>Lottia gigantea</i>
Striped shore crab	<i>Pachygrapsus crassipes</i>
Hairy hermit crab	<i>Pagurus hirsutiussculus</i>
Blue - clawed hermit crab	<i>P. samuelis</i>
Tide pool sculpins	<i>Clinocottus analis</i>
Opaleyes	<i>Girella nigricans</i>
Tube-building snail	<i>Aletes squamigerus</i>
Right-handed chama clam	<i>Chama pellucida</i>
Left-handed chama clam	<i>Pseudochama exogrya</i>

Table II-14 (continued)

Nuttall chiton	<i>Nuttalina californica</i>
Mossy chiton	<i>Mopalin muscona</i>
Conspicuous chiton	<i>Stenoplax conspicua</i>
Zone 3: Middle Tide Zone	
California mussel	<i>Mytilus californianus</i>
Goose barnacle	<i>Pollicipes polymerus</i>
Ochre seastar	<i>Pisaster ochraceus</i>
Clam worm	<i>Nereis vexillosa</i>
Porcelain crab	<i>Petrolisthes cinctipes</i>
Scale worm	<i>Halosydna californica</i>
Speckled pillbug	<i>Cirolana harfordi</i>
Aggregate sea anemone	<i>Anthopleura elegantissima</i>
Giant green anemone	<i>Anthopleura xanthogrammica</i>
Pink barnacle	<i>Balanus tintinnabulum</i>
Thatched barnacle	<i>Tetraclita squamosa</i>
Ringed serpent star	<i>Ophionereis annulata</i>
Fuzzy brittle star	<i>Ophiothrix spiculata</i>
Pistol shrimp	<i>Crangon dentipes</i>
Angular unicorn snail	<i>Acanthina spirata</i>
Purple olive snail	<i>Olivella biplicata</i>
Gem murex snail	<i>Maxwellia gemma</i>
California cone snail	<i>Conus californicus</i>
Livid macron snail	<i>Macron lividus</i>

Table II-14 (continued)

Volcano limpet	<i>Fissurella volcano</i>
Sea horse	<i>Aplysia californica</i>
Two spotted octopus	<i>Octopus bimaculoides</i>
Green abalone	<i>Haliotis fulgens</i> juvenals
Black abalone	<i>Haliotis cracherodi</i> "

Zone 4: Low tide zone

Sponges and many plantlike animals, bryzoa, hydroids and tunicates	
Spiny lobster	<i>Panulirus interruptus</i>
Smooth turban snail	<i>Norrisia norrisi</i>
Giant keyhole limpet	<i>Megathura crenulata</i>

iii Benthic Invertebrate Communities

(1) Concept of Benthic Communities

In the classical studies, bottom communities in the sea are recognized, defined and named for one or more conspicuous and dominant animal that aggregate in sufficient numbers to be collected in small samples. In this way, the benthos can be divided into bands (patches) of dominant organisms and their associates. The associated organisms may be larger in size but fewer, or smaller in size and either more or less numerous than the dominants. Dominant organisms are selected by their preponderance of weight (standing crop) per unit of area coupled with a given level of frequency suited to the sampling technique. If a coarse net were used to collect large sea urchins, the community might be named for the urchin. On the other hand if a finer mesh net were used a smaller organism might be more abundant and of more importance in the standing crop. Thus the use of "Ophiuroid Community", or "Holothurian Community", etc., is an appellation based on subjective information.

Some of the common communities that have been described were named for various forms of pelecypods, echinoids, ophiuroids, gastropods, polychaetes and crustaceans (Thorson, 1957 and Hedgpeth, 1957).

Thorson (1950) and Jones (1950) have stated the need for worldwide descriptive techniques for marine benthic communities. Of particular importance is the need for a comparative faunal analysis of similar communities. Crucial to this issue is the fact that present day sampling techniques are not overly different from those of the past. Because of this, recent efforts have been aimed at the development of

diversity measures to aid in the description of marine benthic communities (Fager, 1972; Margalef, 1958, 1968; Sanders, 1968, 1969; and Shannon and Weaver, 1963). Numerical diversity indices are desirable for a number of reasons: 1) a numerical index calculated by a specific formula is an objective measure than can be verified by other investigators; 2) although taxonomic expertise is required for species identification, knowledge of the sensitivity or tolerance of the various species to pollution or other stress is not necessary; and 3) diversity indices appear to provide a rather sensitive indication of community structural changes and are not as subject to the wide natural variability that is a problem with biomass or abundance. Also, species diversity can illustrate two important comparable facets: 1) number of species/given location, and 2) degree of evenness of distribution of individuals within a species.

(2) Rocky Intertidal

Areas having rocky shores or rocky outcrops on otherwise sandy beaches have a larger and more diverse intertidal community than sandy beaches. The total area comprising the rocky intertidal habitat varies seasonally. The heavy surf during the winter greatly increases the amount of rocky shores as it washes much of the sand away from the beaches. The movement of sand is important to the state of the rocky intertidal community. It can smother existing intertidal organisms, interfere with spawning and larval activities in addition to changing the amount of rocky shore available to the intertidal community.

Intertidal zonation has been well studied in several areas, and a number of descriptive systems have been proposed for "ease" of classifying habitats and summarizing their populations (Batzli, 1969; Colman, 1933; Dayton, 1971; Doty, 1946, 1957; Elton, 1946; Endean et al, 1956; Lewis, 1964; Southward, 1958; Ricketts, Calvin and Hedgpeth, 1968; and Stephenson and Stephenson, 1949, 1972).

On the California coast there are a number of faunal lists, overview accounts and limited (species-wise and geographical) ecology/zonation accounts: Barnard, 1969; Caplan and Boolootian, 1967; Connel, 1961; Emerson, 1971; Fauchald, 1971; Fay, 1972; Reish, 1969; SCCWRP, 1973; Stephenson and Stephenson, 1972; and Turner et al., 1968.

The relative duration and periods of tidal exposure are important aspects of the rocky shore intertidal community. Because of the degree of tidal exposure the community changes over a vertical distance of only several feet. Rocky shore intertidal communities are distinguished and classified by their vertical zonation and we will follow the classification of Ricketts, Calvin and Hedgpeth (1968) in this narrative.

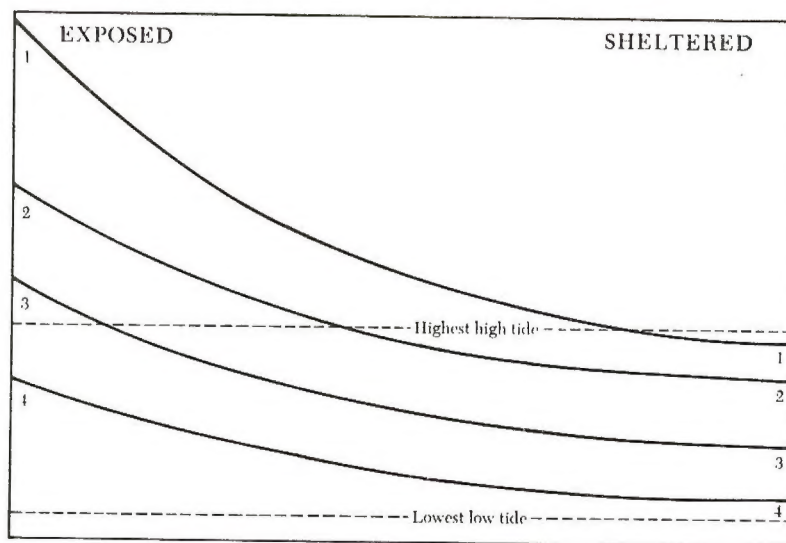
Another important ecological factor on a rocky shore intertidal community is the degree of wave shock. With increased wave force the difficulty of an organism to hold on to the substrate or otherwise maintain its position increases. The degree of wave shock can modify the vertical zonation pattern of a semi-protected area and alter the species composition of the community.

Ricketts et al. (1968) concluded that a vertical zonation of the rocky intertidal community into four units was the most practical. Their classification is summarized as follows:

- Zone 1 Splash zone (supralittoral or Littorina zone)
 (5 ft. above low mean tide)
- Zone 2 High tide on upper horizon (5 ft. to 2.5 ft. above
 low mean tide)
- Zone 3 Mid tide, or middle horizon (2.5 ft. to 0 ft. above
 low mean tide)
- Zone 4 Low tide or lower horizon (uncovered only at minus
 tide)

These zones, however, are not immutably fixed according to tidal levels, but tend to spread wider and higher toward the region of heavier wave action (Figure II-36). Often this can be seen on exposed coasts, along a vertical face set at right angles to the main direction of the waves. The conspicuous mussel zone will be wider toward the sea. What is not so obvious to the casual observer is that in very sheltered regions the whole zonal pattern may be lowered so that the uppermost zone is actually below the highest water mark of the year, as Figure II-36 suggests. The generalized zonal pattern described here is essentially a summary of observations of a semiprotected coastal situation.

Along the surf-swept open coast, the rocky cliffs of the inaptly named Pacific have developed associations of animals with phenomenal staying power and resistance to wave shock. It is not the fact that these animals will not live elsewhere that makes them characteristic, but the fact that no other animals can tolerate the rigorous conditions of heavy surf. Obviously, the prime requisites here are the ability to hold on in the face of breaking waves and the possession of structures fit to resist the sudden impact of tons of water. These neces-



4. The zones are displaced upward as one proceeds toward the more exposed part of the coast; such a displacement is often seen on rocky headlands. This is a schematic diagram, and it is not intended to indicate actual height.

Figure II-36 From: Ricketts, Calvin and Hedgpeth (1968)

sities have produced the tough skins and heavy shells generally present, the strong tube feet of seastars, and the horny threads of natural plastic by which mussels are attached.

The force of the waves on stretches of completely open coast is so great that animals up near the high-tide line are wetted by spray on all but the lowest tides. Consequently, there is not the relatively sharp zonation that we find elsewhere, and some of the most obvious animals are fairly well distributed throughout the intertidal zone.

Ricketts and Calvin described the various vertical zones and habitats within them. These descriptions are applied to rocky shores in general.

1. Spray zone - This is a bare rock area in the main, but sometimes there are sparse growths of green algae. It is inhabited by hardy, semiterrestrial animals.

2. High tide zone - In this belt there is a greater variety of species and a tremendously greater number of individuals of many of the species represented than in the highest zone. Here there are some more or less permanent tide pools, with their active fauna of hermit crabs, snails, and crabs. Barnacles occur here also, certainly larger and possibly in greater abundance. Plants begin to appear in the uppermost part of this zone, and grow lush in its lower part. These plants not only provide bases of attachment for sessile animals but furnish shelter for others that adhere to the rock, and protect them from dessiccation.

3. Mid tide zone - This area, zone 3, is below mean sea level and is largely uncovered by most low tides and covered by most high

tides. The higher zones seem relatively barren by comparison with the teeming life of this mid-region, which is exceeded in density only by that of the outer tidelands. Here plants grow in great profusion. These plants, in providing protection from deadly sunlight and drying, are of importance to the animals, which are predominantly intertidal forms and rarely occur in deep water.

The variety of animals associated in this zone is so great that it seems desirable to consider them according to a further division of habitat, as follows; exposed rock, protected rock, under-rock, burrowing, pool, root and holdfast.

Exposed Rock Habitat

These are animals living on the tops and sides of rocks and ledges, exposed to waves, sun and wind.

Protected Rock Habitat

Animals here are attached to, or living on, protected rocks and rockweed. Many of the commonest inhabitants of this subregion can scarcely be considered obvious, since in order to see them advantageously one must almost lie down in the pools, looking up into the crevices and under ledges.

Under-Rock Habitat

These are animals found on the underside of loosely embedded rocks (but not in the substratum) or between adjacent rocks and boulders where there is no accumulation of substratum. This area offers the maximum of protection from wave shock, sunlight, and desiccation.

Burrowing Habitat

Animals of the burrowing habitat occur in the mud, sand, or gravel substratum underlying tide-pool rocks. The surface boulders are often resting on a matrix of muddy gravel bound together by chunks of rock of varying sizes. The normal expectancy would be that the sand or mud under rocks would harbor forms similar to those burrowing in the sand or mud of estuaries. This proves true to some extent, although the under-rock substratum animals actually seem to form a fairly specific assemblage.

The tide pools are small depressions filled with water even during low tide. Water temperatures reach extreme highs during the summer and salinities can fluctuate greatly during rainfall or because of high air temperatures.

4. Low tide zone - Many of the middle-horizon animals occur here also, but much of the population consists of animals unable to exist higher up and not so accustomed to the rhythm of the tides. This tremendously crowded environment contributes a greater number of species than all the other tidal levels. Not only do the waters teem, but there is no rock too small to harbor some living thing, and no single cluster of algae without its inhabitants. Since these creatures live and thrive in an environment that seems utterly strange to us, it is no wonder that we find interest in their ways of feeding, of breathing, of holding on, of ensuring the continuity of their kind, or in their strangely different weapons and methods of attack and escape. In this zone, very few animals are exposed to wave action, sun, and wind on unprotected rock faces, except on open coasts where the surf is high.

The habitats of rock, under-rock, burrowing, etc. are also present at the low tide zone.

The common conspicuous and characteristic intertidal animals of Southern California Rocky Shores are presented on Table II-14 (Hedgpeth and Hinton, 1961).

Allan Hancock Foundation (1965) observed three intertidal areas representative of Southern California around Los Angeles or to the south.

Abalone Cove on the Palos Verdes Peninsula is characterized by large boulders partly buried in a brown sandy beach. At its outer end it gives rise to kelp beds in shallower water, and large concentrations of the polychaete *Chaetopterus*. Abalone Cove (observed February 1957) is one of several indentations of the Palos Verdes Peninsula and may be considered characteristic of numerous other similar coves on the mainland and the offshore islands. At Abalone Cove, a sandy beach is partly strewn with scattered tilted sandstone rocks at the highest level and with shaley rocks at a lower level where high tides completely cover them. Large basaltic rocks form a barrier at the southernmost end of the cove. A community dominated by the bivalve mussel *Mytilus californianus* and the tube worm *Phragmatopoma californica* was described and shown on Table II- 15.

The entrance to Ballona Creek near Venice is characterized by rock-surfaced jetties in brown sandy backshores behind a broad sandy beach.

The beach at the entrance of Ballona Creek (observed November 1956) is characterized by two rock jetties extending at right angles to shore directing the flow of water from the creek seaward, or from tide water

into the lagoon. The upper parts of jetties are occasionally covered by spray, and the lower walls are exposed only at low tide levels.

A community dominated by the bivalve mussel *Mytilus edulis* and the stalked barnacle *Pollicipes polymerus* = *Mitella polymerus* was described and is shown on Table II-16. The Allan Hancock Foundation did not utilize the vertical zonation of Ricketts and Calvin, but noted a vertical distribution of the species. These descriptions were adapted to Rickett's vertical zones on the tables.

Table II-25 shows the intertidal organisms collected along the Southern California Coast during 1969 and 1970 by Nicholson and Cimberg (1971) and the collecting locations are shown on Fig. II-37. According to Ricketts, Calvin and Hedgpeth (1968) the assemblage of *Mytilus californianus* (mussel), *Pollicipes polymerus* (stalked barnacle) and *Pisaster ochraceus* (ocher seastar) are characteristic of the most severely wave struck rocky shores. Although the mussel and stalked barnacle members of the assemblage were wide spread, Table II-17 indicates the ocher seastar was consistently present only at North Dana Point and relatively consistent at the East Cabrillo and Corona del Mar stations. These data indicate that the majority of stations sampled during the study had some degree of protection from the most severe waves.

Table II-15 *Mytilus californianus*-*Phragmatopoma* Rocky Shore Intertidal
community at Abalone Cove (Allan Hancock Foundation, 1965)

Splash zone

Periwinkle snail	<i>Littorina planaxis</i>
Limpets	<i>Acmaea</i> spp.

Hightide zone

Blue mussel	<i>Mytilus californianus</i>
Green anemone	<i>Anthopleura xanthogrammica</i>
Striped shore-crab	<i>Pachygrapsus crassipes</i>

Mid tide zone

Tube worm	<i>Phragmatopoma californica</i>
Moss chiton	<i>Molpadia mucosa</i>
Rock - oyster	<i>Anomia peruviana</i>
Black abalone	<i>Haliotis cracherodii</i>
Hermit crabs	Paguridae
Spider crab	<i>Pugettia</i> sp.
Shore crab	<i>Hemigrapsus</i> sp.
Purple snail	<i>Tegula funebris</i>
White clam	<i>Chama pelludica</i>
Naked hydroids	Various species, especially syncorinids
Tunicate	<i>Eudistoma diaphana</i>

Low tide zone

Cirratulid worm	<i>Dodecaceria fewkesii</i>
Nereid worm	<i>Platynereis bicanaliculata</i>

The subintertidal levels, to the 18-foot depth level, were partly explored by David Scholl graduate student in geology at the University of Southern California, by skin diving. The conspicuous and more abundant organisms include the following:

large kelps, *Macrocystis*
abalones, *Haliotis rufescens*, *H. fulgens* and *H. corrugata*
a large brown snail, *Norrisia norrisii*, grazing on kelps
the cone shell, *Conus californicus*
a large knobbed snail, *Astraea undosa*
spiny lobsters, *Panulirus interruptus*
the spiny ophiuroid, *Ophiothrix spiculata*
and key-hole limpets, *Megathuria crenulata*.

(3) Sandy Intertidal

Approximately 80% of the Southern California mainland coast has sandy beaches. This is in sharp contrast with the offshore islands which, with the exception of San Nicolas Island, have predominately rocky shores (California Department of Fish and Game, 1973). Approximately 83.5 miles (76 percent) of Santa Barbara County's shoreline is classed as sandy beach. The shoreline classification of the remaining Southern California counties are tabulated below:

<u>County</u>	<u>Sandy beaches</u>		<u>Rocky shores</u>	
	<u>Miles</u>	<u>%</u>	<u>Miles</u>	<u>%</u>
Ventura	38	93	3	7
Los Angeles	51	77	26	24
Orange	38	92	3	8
San Diego	<u>65</u>	<u>85</u>	<u>11</u>	<u>15</u>
Total	192	81	43	19

Graphic 10 shows the locations of sandy beaches and was taken from Corps of Engineers and Dames and Moore (1971).

The environment of the exposed sandy intertidal is considerably less stable than that of the rocky intertidal. Every wave on a sandy intertidal beach moves a great deal of sand. Large waves in the winter carry much of the sand away, while smaller waves of summer wash the sand back up on the beach - this is called littoral drift (Hedgpeth,

Table II-16 *Mytilus edulis* - (*Pollicipes*) Rocky shore Intertidal Community
at Ballona Creek (Allan Hancock Foundation, 1965)

Top Zone (5 ft. above low mean tide)

Periwinkle snails	<i>Littorina</i> sp.
Acorn barnacle	<i>Balanus (glandula)</i> ?
Acorn barnacle	<i>Cthalamus (fissus)</i> ?

Hightide Zone

Mussel	<i>Mytilus edulis</i>
White clams	<i>Kellia suborbichlaris</i>
" "	<i>Petricola carditoides</i>
Clam	<i>Prothothaca staminea</i>
Nemertean	<i>Emplectonema gracile</i>

Mid tide Zone

Stalked barnacle	<i>Pollicipes polymerus</i> = <i>Mitella polymerus</i>
Amphipods	<i>Hyale frequens</i>
"	<i>Corophium insidiosum</i>
	Small oligochaete

Low tide Zone

Green anemone	<i>Anthopleura xanthogammica</i>
anemone	anemone sp
Branching hydroids and bryozoans	

Table II-16 (continued)

The identified polychaetes include:

- Boccardia proboscidia* abundant in lower levels of
Mytilus zone
- Cirriiformia spirabrancha*, juveniles, in sandy
pockets
- Dorvillea articulata*, several in detrital clumps
- Eulalia*, black banded
- Halosydna brevisetosa* in crevices of *Mytilus* colony
- Hemipodus borealis* in sandy niches
- Lumbrineris zonata* in sands at low tidal levels
- Naineris dendritica* in sandy gravelly crevices
- Neris latescens*, most abundant at lower level of
Mytilus colony
- Nereis mediator*, in middle to high zone of *Mytilus*,
common
- Paleanotus bellis*, in low crevices
- Podarke pugettensis*
- Polydora limicola*, in silt covered mucoid, massed
tubes, abundant
- Polyopthalmus pictus*, in algal clumps
- Syllis fasciata*, common in *Mytilus* zone

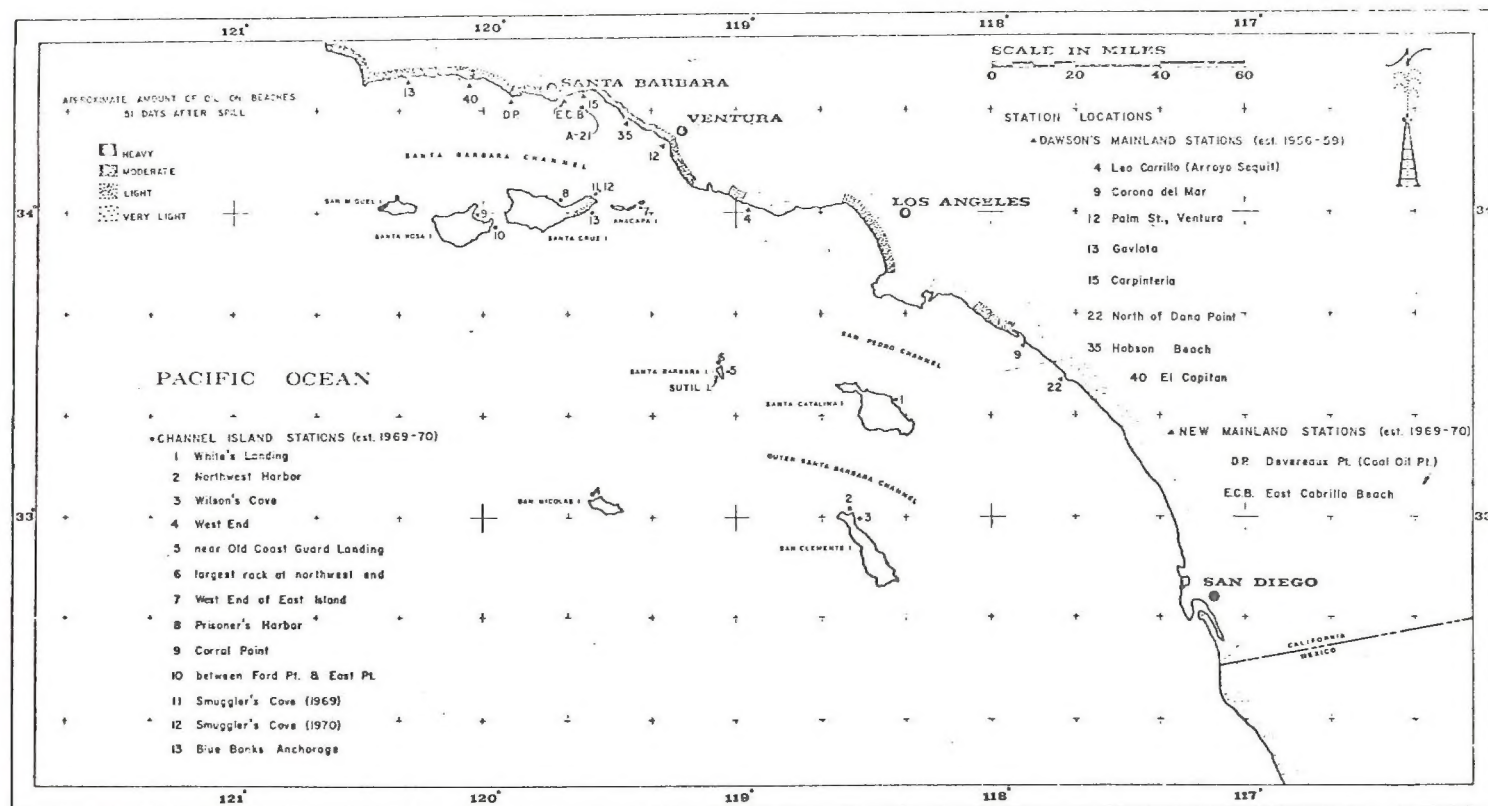


Fig. II-37 Rocky shore collection locations 1969 and 1970 (Nicholson and Cimberg, 1971)

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Marine animals reported at mainland stations, 1969-1970.

A Stethion line was covered by sand, all data is from rocky new west, 50 yards.

STATION	DATE	LOCATION
13	6/69	Gaviota
13	7/69	Gaviota
13	8/69	Gaviota
13	9/69	Gaviota
13	10/69	Gaviota
13	11/69	Gaviota
13	12/69	Gaviota
13	1/70	Gaviota
13	2/70	Gaviota
13	3/70	Gaviota
13	4/70	Gaviota
13	5/70	Gaviota
13	6/70	Gaviota
40	6/69	E. Capitan
40	7/69	E. Capitan
40	8/69	E. Capitan
40	9/69	E. Capitan
40	10/69	E. Capitan
40	11/69	E. Capitan
40	12/69	E. Capitan
40	1/70	E. Capitan
40	2/70	E. Capitan
40	3/70	E. Capitan
40	4/70	E. Capitan
40	5/70	E. Capitan
40	6/70	E. Capitan
25	6/69	Coal Oil Pt.
25	7/69	Coal Oil Pt.
25	8/69	Coal Oil Pt.
25	9/69	Coal Oil Pt.
25	10/69	Coal Oil Pt.
25	11/69	Coal Oil Pt.
25	12/69	Coal Oil Pt.
25	1/70	Coal Oil Pt.
25	2/70	Coal Oil Pt.
25	3/70	Coal Oil Pt.
25	4/70	Coal Oil Pt.
25	5/70	Coal Oil Pt.
25	6/70	Coal Oil Pt.
15	6/69	East Cañuelo
15	7/69	East Cañuelo
15	8/69	East Cañuelo
15	9/69	East Cañuelo
15	10/69	East Cañuelo
15	11/69	East Cañuelo
15	12/69	East Cañuelo
15	1/70	East Cañuelo
15	2/70	East Cañuelo
15	3/70	East Cañuelo
15	4/70	East Cañuelo
15	5/70	East Cañuelo
15	6/70	East Cañuelo
35	6/69	Corpenria
35	7/69	Corpenria
35	8/69	Corpenria
35	9/69	Corpenria
35	10/69	Corpenria
35	11/69	Corpenria
35	12/69	Corpenria
35	1/70	Corpenria
35	2/70	Corpenria
35	3/70	Corpenria
35	4/70	Corpenria
35	5/70	Corpenria
35	6/70	Corpenria
35	7/70	Corpenria
35	8/70	Corpenria
35	9/70	Corpenria
35	10/70	Corpenria
35	11/70	Corpenria
35	12/70	Corpenria
35	1/71	Corpenria
35	2/71	Corpenria
35	3/71	Corpenria
35	4/71	Corpenria
35	5/71	Corpenria
35	6/71	Corpenria
35	7/71	Corpenria
35	8/71	Corpenria
35	9/71	Corpenria
35	10/71	Corpenria
35	11/71	Corpenria
35	12/71	Corpenria
35	1/72	Corpenria
35	2/72	Corpenria
35	3/72	Corpenria
35	4/72	Corpenria
35	5/72	Corpenria
35	6/72	Corpenria
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35	11/72	Corpenria
35	12/72	Corpenria
35	1/73	Corpenria
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35	12/73	Corpenria
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35	12/74	Corpenria
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35	12/75	Corpenria
35	1/76	Corpenria
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35	8/91	Corpenria
35	9/91	Corpenria
35	10/91	Corpenria
35	11/91	Corpenria
35	12/91	Corpenria
35	1/92	Corpenria
35	2/92	Corpenria
35	3/92	Corpenria
35	4/92	Corpenria
35	5/92	Corpenria
35	6/92	Corpenria
35	7/92	Corpenria
35	8/92	Corpenria
35	9/92	Corpenria
35	10/92	Corpenria
35	11/92	Corpenria
35	12/92	Corpenria
35	1/93	Corpenria
35	2/93	Corpenria
35	3/93	Corpenria
35	4/93	Corpenria
35	5/93	Corpenria
35	6/93	Corpenria
35	7/93	Corpenria
35	8/93	Corpenria
35	9/93	Corpenria
35	10/93	Corpenria
35	11/93	Corpenria
35	12/93	Corpenria
35	1/94	Corpenria
35	2/94	Corpenria
35	3/94	Corpenria
35	4/94	Corpenria
35	5/94	Corpenria
35	6/94	Corpenria
35	7/94	Corpenria
35	8/94	Corpenria
35	9/94	Corpenria
35	10/94	Corpenria
35	11/94	Corpenria
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35	11/95	Corpenria
35	12/95	Corpenria
35	1/96	Corpenria
35	2/96	Corpenria
35	3/96	Corpenria
35	4/96	Corpenria
35	5/96	Corpenria
35	6/96	Corpenria
35	7/96	Corpenria
35	8/96	Corpenria
35	9/96	Corpenria
35	10/96	Corpenria
35	11/96	Corpenria
35	12/96	Corpenria
35	1/97	Corpenria
35	2/97	Corpenria
35	3/97	Corpenria
35	4/97	Corpenria
35	5/97	Corpenria
35	6/97	Corpenria
35	7/97	Corpenria
35	8/97	Corpenria
35	9/97	Corpenria
35	10/97	Corpenria
35	11/97	Corpenria
35	12/97	Corpenria
35	1/98	Corpenria
35	2/98	Corpenria
35	3/98	Corpenria
35	4/98	Corpenria
35	5/98	Corpenria
35	6/98	Corpenria
35	7/98	Corpenria
35	8/98	Corpenria
35	9/98	Corpenria
35	10/98	Corpenria
35	11/98	Corpenria
35	12/98	Corpenria
35	1/99	Corpenria
35	2/99	Corpenria
35	3/99	Corpenria
35	4/99	Corpenria
35	5/99	Corpenria
35	6/99	Corpenria
35	7/99	Corpenria
35	8/99	Corpenria
35	9/99	Corpenria
35	10/99	Corpenria
35	11/99	Corpenria
35	12/99	Corpenria
35	1/00	Corpenria
35	2/00	Corpenria
35	3/00	Corpenria
35	4/00	Corpenria
35	5/00	Corpenria
35	6/00	Corpenria
35	7/00	Corpenria
35	8/00	Corpenria
35	9/00	Corpenria
35	10/00	Corpenria
35	11/00	Corpenria
35	12/00	Corpenria
35	1/01	Corpenria
35	2/01	Corpenria
35	3/01	Corpenria
35	4/01	Corpenria
35		

1957; Ingle, 1966).

Animals living on surf-swept rocky intertidal areas have solved the problem of wave shock by evolving powerful attachment devices or cryptic habits. Organisms on surf-swept sandy beaches achieve the same by burrowing (burying) themselves in the sand. That "exposed living" on a sandy area is insuperable is indicated by the fact that so few organisms do exist. That sandy beaches have limited populations is not unexpected.

Because of the continued restructuring of sandy beaches the number of individuals per species varies greatly from year to year. There is however, a characteristic group of animals which live just below the low tide line or within the sand between the tide lines. A few even live higher up the beach in burrows or beneath organic debris. Some of these organisms are active only at night or on cloudy days, others remain hidden in the sand. Additional, general comments are presented by Cubitt (1969), Fager (1968), MacGinitie and MacGinitie (1949), Ricketts et al. (1968), McConnaughey (1970), and Trask (1970).

Organisms occurring on/in sandy beach areas are categorized by: size (macrofauna and meiofauna) and character of the integument (soft or hard). The new definition of meiofauna is animals which can pass a 1.0 mm to 0.5 mm screen. See Hulings and Gray (1971) for a general discussion of meiofauna. Meiofauna, particularly nematods, are extremely numerous and very important to the ecology of sandy bottoms.

As for the rocky intertidal, accounts dealing with sandy areas are few. The following list of common Southern California sandy intertidal macrofaunal invertebrates was erected from a number of scattered

references: Burch (1944-46); Cubit (1969); Efford (1965, 1966); Fitch (1953); Keen (1937); Keen and Coan (1974); Keen and Pearson (1952); and MacGinitie (1938).

PLATYHELMINTHES

Convoluta

CNIDARIA

Clytia bakeri

ANNELIDA (POLYCHAETA)

Dispio uncinata

Eteone spp.

Euzonus mucronata

Hemipodus californiensis

Lumbrineris zonata

Magelona pitelkai

Mediomastus acutus

Nephtys californiensis

Nerinides acuta

Scoloplos armiger

Thoracophelia mucronata

MOLLUSCA

Olivella biplicata

Donax gouldi

Tivela stultorum

Siliqua patula

Polinices lewisii

Terebra pedroana

CRUSTACEA

Ancinus seticomus

Archeomysis maculata

Cirolana chiltoni

Emerita analoga

Lepidopa myops

Orchestoidea californiana

Orchestoidea traskiana

Blepharipoda occidentalis

Table II-18 is a list of epifaunal species recorded by Fager (1968) in a study on a community of invertebrates living on/in sand, La Jolla Bight, California, under water of 5-10 m depth.

(4) Artificial Reefs

Modification of the environment as a means of obtaining conditions favoring increased productivity is not new. It has been used successfully to increase yields in fresh water environments for many years. However, attempts to develop methodology for enhancing marine populations are relatively recent. The construction of thoughtfully placed man-made reefs is such an attempt. However, it is clear that the mere "culturing" of food (fish) species is not adequate, rather there is a need to support the acceleration

Table II-18
List of Sand-bottom epifaunal species.

ANTHROZOA

Harenactis attenuata Torrey
Renilla kollikeri Pfeffer
Stylatula elongata (Gabb)
Zaolutus actius Hand

POLYCHAETA

Diopatra splendidissima Kinberg
Owenia fusiformis Delle Chiaje

MALACOSTRACA

Ancinus sp.
Blepharipoda occidentalis Randall
Cancer gracilis Dana
Crangon nigromaculatus (Lockington)
Holopagurus pilosus Holmes
Heterocrypta occidentalis (Dana)
Inachoides tuberculatus Lockington
Lepidopa myops Stimpson
Portunus xantusii (Stimpson)

GASTROPODA

Acteon punctocaelatus (Carpenter)
Balcis sp. (= micans Carpenter ?)
Epitonium tinctum Carpenter
Nassarius fossatus (Gould)
Nassarius perpinguis (Hinds)
Olivella baetica Carpenter
Olivella biplicata (Sowerby)
Pleurophyllidia californica Cooper
Pleurophyllidia californica Cooper
Polinices recluzianus (Deshayes)
Turbonilla attrita Dall and Bartsch
Turbonilla tridentata Carpenter

Table II-18 (Continued)

ASTEROIDEA

Astropecten armatus Gray
Astropecten californicus Fisher

OPHIUROIDEA

Amphiodia occidentalis (Lyman)
Amphiodia urtica (Lyman)

ECHINOIDEA

Dendraster excentricus (Eschscholtz)

HOLOTHURIOIDEA

Molpadia arenicola (Stimpson)

of "all" the natural events within a given food web. The enhancement of benthic invertebrate populations insures abundant food resources for fish populations. A general review of such efforts can be found in Iversen (1968), McKee (1967), and Unger (1966).

In 1958 the California Department of Fish and Game initiated an Ocean Fish Habitat Development Program. This program was designed to determine: 1) the practicality of artificial (man-made) reefs in Southern California waters; 2) the best materials to use, and 3) the economic return. Published data (Carlisle et al, 1964; and Turner et al, 1969) indicate that in about a five year period such reefs achieve a "natural situation" with fluctuations typical of reef ecosystems.

Benthic invertebrates play a significant role in the initial succession on the reefs e.g., modifying the substratum, providing cryptic areas for other organisms, and serving as the food source for others within the food web. Table II-19 gives a list of the benthic invertebrates together with an indication of their abundance found on test sites at Hermosa Beach, Santa Monica and Malibu, California.

The importance of these tests will only be realized in the next few years as the need for increasing food resources from the sea becomes more apparent.

(5) Subtidal Hard Bottoms

The literature on sublittoral hard bottoms communities off Southern California is scanty and apparently limited to a study of a silt-stone reef off the coast of Corona del Mar (Peguegnat, 1963, 1964, and 1968). Subtidal rocky areas are present around kelp beds and on parts of submarine canyons, but the environ-

Table II-19
ABUNDANCE OF BENTHIC INVERTEBRATES RECORDED
FROM MAN-MADE REEF STUDIES*

Organisms	Composition of Reef			
	Street cars	Automobile Bodies	Rock-pile	Concrete Shelters
PROTOZOA				
Folliculina sp.			R	
Gromia oviformis			R	
PORIFERA				
Leucosolenia botryoides			R	C
Leucosolenia sp.	R			C
CNIDARIA				
HYDROZOA				
Bimeria sp.				A
Bougainvillea sp., cf. mertensi	C			C
Campanularia sp.	C			
Clytia kincaidi			C	
Clytia sp.		C	C	
Eudendrium sp., cf. ramosum				R
Garveia sp.		R	R	C
Hydroid (unid.)	C	R	C	C
Obelia sp., cf. dichotoma	R	A	C/A	R
Obelia sp., cf. equilateralis			A	
Obelia sp., cf. gracilis	C		C	R
Obelia sp., cf. obtusidens	A			
Obelia sp., cf. plicata			C	
Obelia sp.	C		A/C	R
ANTHOZOA				
Coryractus californica	R			
PLATYHELMINTHES				
Polycladia	A	A	A	A
NEMERTINA				
	A	C	A	A
ANNELIDA				
POLYCHAETA				
Ampharetidae				R
Arabellidae	R			
Chaetopteridae	R			R
Chrysopetalidae	A	A	A	A
Cirratulidae	R			
Dorvilleidae	R			R
Flabelligeridae			R	
Hesionidae	A	C	C	C
Lumbrineridae	R			R
Nereidae	A	A	A	A
Onuphidae			R	R
Opheliidae	A	R	C	C

A=abundant C=common R=rare

*Compilation of results for 3 locations: Hermosa Beach, Santa Monica and Malibu

Organisms	Street cars	Automobile Bodies	Rock-pile	Concrete Shelters
Orbiniidae				R
Phyllodocidae	A	C	C	A
Polynoidae	R		R	A
Polychaete (Unid.)	A	C	A	A
Sabellariidae	A		A	A
Sabellidae	A	C	A	A
Serpulidae	C	R	C	C
Spionidae	A	C	A	A
Syllidae	A	C	A	A
Terebellidae			R	R
Trichobranchidae	R		R	
SIPUNCULOIDEA				
Phascolosoma agassizii	R		R	
CRUSTACEA				
COPEPODA	A	A	A	A
OSTRACODA	R	R	C	C
CIRRIPIEDIA				
Balanus concavus pacificus	A	A	A	A
Balanus sp.	A	A	A	A
Balanus sp. cf. concavus pacificus			A	A
Balanus tintinnabulum californicus				R
Balanus trigonus	A	R	A	C
CUMACEA				
ISOPODA				
Caprellidea	A	A	A	A
Gammaridea	A	A	A	A
Limnoria tripunctata	C	A	A	A
Mesoporcellio sp.				R
TANAIDACEA			R	
DECAPODA				
Cancer sp.	R		R	R
Crab (Unid.)	R	R	R	R
Loxorhynchus sp.	R		R	
Pugettia sp.				R
Pychogonida	R		R	R
Shrimp (Unid.)	R		R	R
Spirontocaris palpator	R		R	R
MOLLUSCA				
PELECYPODA				
Arcuatula demissa				R
Bankia setacea	A	A	A	A
Chama pellucida			R	R
Hiatella arctica	A	R	R	A
Hinnites multirugosus				R
Kellia laperousii	A	R	R	A
Leptopecten latiauratus	A		A	A

Organisms	Composition of Reef			
	Street cars	Automobile Bodies	Rock-pile	Concrete Shelters
<i>Modiolus capax</i>	R			R
<i>Mutilus edulis</i>	R		R	
<i>Polycepod (Unid.)</i>				R
<i>Pododesmus cepio</i>	C		C	A
<i>Teredo navalis</i>				R
<i>Xylophaga sp.</i>	C	R	C	C
GASTROPODA				
<i>Acanthodoris lutea</i>	C	R	R	A
<i>Barleeia sp.</i>				R
<i>Crepidula adunca</i>	R			
<i>Crepidula onyx</i>	R			R
<i>Crepidula perforans</i>			R	
<i>Crepidatella lingulata</i>	R	R	R	R
<i>Dendronotus frondosus</i>			R	R
<i>Dirona albolineata</i>	R			R
<i>Doto sp.</i>	R		R	R
<i>Hemissenda crassicornis</i>	R	C	R	C
<i>Mitrella carinata</i>				R
Nudibranch (Unid. aeolid)	A	R	C	A
Nudibranch (Unid. dorid)	A		R	A
ECTOPROCTA				
<i>Callopora circumclathrata</i>			C	R
<i>Callopora sp.</i>	R			
<i>Thalamoporella californica</i>				R
<i>Tubulipora admiranda</i>	R	R	R	R
<i>Victorella argilla</i>	A	R	C	C
ENTOPROCTA				
<i>Barentsin discreta</i>	C		R	

mental conditions of these areas are somewhat different than the raised reef discussed by Peguegnat.

Off Corona del Mar are two reefs approximately 200 m and 500 m from shore (Fig. II-38). The 500 m reef, in water depths of 9.5 to 18 m depth, was intensely studied and is reported on here.

The degree of water movement on the reef, which results primarily from the propagation of surface waves, varies inversely with depth. It was suggested that this pattern of water movement determines the distribution of the major units of the epifauna through its effects upon the availability of food of different types at particular points on the reef. Suspended organic matter is not only more abundant on the upper levels of the reef, but its rate of delivery to crust-forming organisms is enhanced by turbulence. Deposition of organic materials removed from the upper part of the reef is facilitated by the sharp reduction in degree of water movement along the lower sides and bottom of the reef.

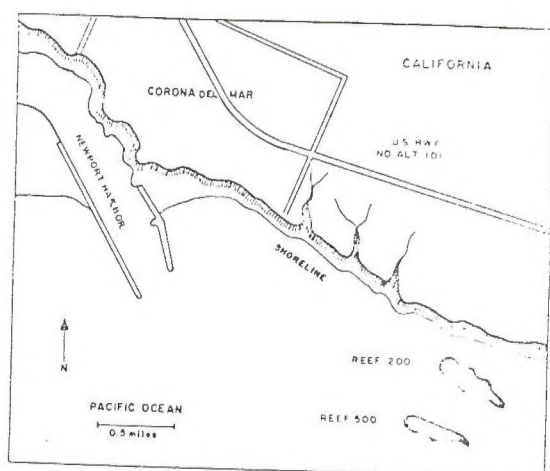
The depth differential of the reef was great enough to involve vertical temperature difference of as much as 6°C. The part of Reef 500 above the thermocline exhibits faunal affinities to southern epifaunas, e.g., in regard to densities of the rock oyster *Chama pellucida* and associated species, whereas other species with northern affinities, such as *Henricia leviuscula*, occur only at the reef base and are absent from the shallower Reef 200.

The high population densities as well as large number of species per unit area characteristic of shallow sublittoral epifaunas may prove to exceed those in other biotopes of either land or sea. Between 300 and 400 described species of macroscopic invertebrates distributed among 12 phyla lived on the reef complex, which has a surface of only 1,385m², including a meter-wide strip of soft bottom encircling the rock. Moreover, about 90% of the invertebrates and more than half

the fishes included in this study were confined to, or are directly dependent upon, the 1,200m² of rocky substratum.

Although changing conditions associated with the highly irregular rocky surface create a high degree of patchiness in the epifauna, within any of the zones some aggregations of species were sufficiently uniform and widespread to permit recognition of communities. In general the predominant species in the upper 2 zones are sessile suspension feeders, which form thick incrustations that form biotopes for large numbers of small sessile and motile species. In the lower zones, on the other hand, the predominant species tend to be motile scavengers and deposit feeders, and the incrustations that are present are thin and formed by single species. These zones, together with their general depth limits along the transect where the sampling was done, are: Reef-top Zone, 9.5-12.5 m, where the important epifaunal feature is an incrustation formed by the rock oyster *Chama pellucida*; the Mid-reef Zone, 12.5-14.5 m, which supports a thick growth of calcareous ectoprocts; the Reef-base Zone, 14.5-16.5 m, where large sea urchins and deposit-feeding sea cucumbers predominate; and the Mixed-bottom Zone, 16.5 +m, which is located on the adjacent sea bottom of sediments and rock slabs and which supports a mixture of infaunal and epifaunal species.

There was a general top-to-bottom decline in biomass, number of species, and individuals. These relationships as well as vertical changes in feeding types are numerically illustrated on Tables II-20 and II-21. The vertical population densities of the principal species are shown on Table II-22.



Location of the submarine rock reefs under study in relation to the city of Corona del Mar (Orange County), Newport Harbor, and the shore.

Fig. II-38 From: Pequegnat (1964)

Table II-20 From: Pequegnat (1968)

Comparative biological and physical data on the epifaunal zones of Reef 500. The last 2 columns compare the number of individuals cm^2 of reef surface on Reef 200 with Reef 500

Zone	Area (m^2)	Depth (m)	No. of species with max. pop. in zone	No. of species in zone	Mean of species per 0.1 m^2 plot	Numerable species 0.1 m^2	Individuals per cm^2	
							Reef 200	Reef 500
Reef top.....	550	9.5-12.5	131	189	89	65	1.40	2.55
Mid-reef.....	400	12.5-14.5	87	144	80	47	0.86	0.95
Reef base.....	250	14.5-16.5	51	114	49	32	0.37	0.32
Mixed-bottom.....	185	16.5-18.5	31	47	23	23	0.03	0.06

Table II-21 From: Pequegnat (1968)

DISTRIBUTION OF DRY-WEIGHT BIOMASS ON REEF 500 BY ZONES AND BY PRINCIPAL FEEDING TYPES*									
FEEDING TYPES	REEF-TOP		MID-REEF		REEF-BASE		MIXED-BOTTOM		MEAN WT.
	g/m ²	% wt.	g/m ²	% wt.	g/m ²	% wt.	g/m ²	% wt.	
Suspension-feeders	2238.4	86.4	1120.4	79.6	202.5	53.9	55.6	31.9	904.2
Carnivores	219.8	8.5	128.0	9.1	53.9	14.3	25.0	14.3	106.7
Scavengers	122.8	4.8	117.1	8.3	45.1	12.0	63.3	36.5	87.1
Herbivores	4.1	0.2	37.6	2.7	63.3	16.9	6.6	3.8	27.9
Deposit-feeders	0.1	0.1	4.5	0.3	10.9	2.9	24.0	13.7	9.9
Totals	2585.2		1407.6		375.7		174.5		

* The marked drop in total biomass between the mid-reef and reef-base zones is accounted for in part by lack of water movement and by feeding activities of sea urchins that destroy settling larvae.

Table II-22 From: Pequegnat (1964)

Mean number of individuals per 0.1 m² quadrat by zone. Development of colonial species stated as per cent of quadrat surface covered by colonies

Species	Reef top	Mid-reef	Reef base	Mixed bottom
<i>Hyalis setacea</i>	1033	10	3	0
<i>Chamaelea californica</i>	360	140	12	0
<i>Chamae pollicaria</i>	280	25	1	0
<i>Crepidula fornicata</i>	125	18	9	0
<i>Littoridinella plumula</i>	90	16	3	0
<i>Paracalanus laticornis</i>	57	4	2	0
<i>Phaeocystis gelatinosa</i>	35	10	0	0
<i>Amphileta mucosa</i>	12	5	0	0
<i>Pachycheilus rufus</i>	9	0	0	0
<i>Cucumaria lubraria</i>	4	2.5	0	0
<i>Smilea isomera</i>	2	0	0	0
<i>Muricea californica</i>	0.25	0.10	0.06	0.03
<i>Pisaster giganteus</i>	0.14	0.09	0.06	0.01
<i>Ophiostoma spiculata</i>	40	81	10	1
<i>Pachycheilus pubescens</i>	1.5	5	1	0
<i>Thelepus crispus</i>	1	25	2	0
<i>Paguristes parvus</i>	0	13	0	0
<i>Squilla montana</i>	0	2	0	0
<i>Microstoma aspera</i>	0	2	0	0
<i>Isopoda californica</i>	0	30*	5*	0
<i>Phyllidia pacifica</i>	0	20*	2.5*	0
<i>Cocconeis laticornis</i>	0	2.5*	0	0
<i>Balanus trigonus</i>	70	180	250	0
<i>Astrangia laticornis</i>	10	45	130	0
<i>Nothia inflata</i>	0	0	4	0
<i>Centrostephanus coronatus</i>	0	0.06	0.13	0
<i>Strombocentrotus franciscanus</i>	0	0.01	0.03	0.01
<i>Muricea fruticosa</i>	0	0.06	0.40	0.01
<i>Parastichopus parvirens</i>	0	0.07	0.14	0.04
<i>Nassarius cooperi</i>	0	0	0	18
<i>Diopatra ornata</i>	0	0	0	5.6
<i>Paguristes ulreyi</i>	0	0*	0	4.4
<i>Littoridinella albicans</i>	0	0	0	3.3
<i>Botryllus boudieri</i>	0	0	0	2.8

*A colonial species. Number is per cent of quadrat surface covered by its colonies.

According to R. Given (personal communication, 1974) much of Tanner and Cortez Banks have hard bottoms.

(6) Kelp Beds

The term "kelp bed" includes all the seaweed species occurring in association with the genus *Macrocystis* (see Section II.E.3.a., Murray, 1974).

Study on the various invertebrates common to kelp beds lagged substantially behind botanical studies. The first list of associated fauna was not compiled until the late 1950's (Limbaugh, 1955). By the early 1960's several reports were published (North, 1971). Most of the early studies were prepared as part of a larger study dealing with sewer outfalls (proposed and actual), man-made reefs, etc. (North, 1971).

The kelp bed niche is reasonably well understood, and North (1971) includes four roles which serve to support associated invertebrates: 1) primary production of organic matter and as such a food source for herbivorous invertebrates; 2) provides a substratum for encrusting organisms, primarily filter feeders; 3) provides shelter, in particular a number of different areas for cryptic organisms; and 4) shades the bottom, thus attracting animals that avoid bright light as well as reducing the standing crop of other primary producers.

Table II-31 gives a list of the 74 common benthic invertebrates associated with a kelp bed. The complete Table (Table 10-3) which includes over 625 species can be found in Bright (1974). This list is from North (1971) with slight modification. It should be noted that there is considerable difficulty defining common or characteristic

organisms for a kelp bed, and the notation of "common" in Table II-23 merely indicates occurrence within the kelp bed habitat.

Dependence, both direct and indirect, of benthic invertebrates upon kelp has been clearly demonstrated. Direct dependence is best illustrated by grazers. A number of common invertebrates living near or on the bottom are kelp grazers:

<i>Lytechinus anamesus</i>	White sea urchin
<i>Strongylocentrotus franciscanus</i> ..	Giant red sea urchin
<i>Strongylocentrotus purpuratus</i>	Purple sea urchin
<i>Aplysia californica</i>	Common sea hare
<i>Astraea undosa</i>	Wavy top snail
<i>Haliotis corrugata</i>	Pink abalone
<i>Haliotis fulgens</i>	Green abalone
<i>Haliotis rufescens</i>	Red abalone
<i>Norrisia norrisii</i>	Smooth brown turban snail
<i>Pugettia producta</i>	Common kelp crab
<i>Taliepus nuttalli</i>	Southern kelp crab
<i>Idothea resicata</i>	Kelp isopod
<i>Ampithoe humeralis</i>	Kelp curling amphipod

Extensive analysis of grazing activities was completed by Leighton (1966, 1971) Leighton et al, (1967). Additional accounts are found in Forster (1959); Saito and Nakamura (1961); Clarke (1971); and Jones (1971). Sea urchin studies have evolved in parallel with kelp restoration projects (North, 1958, 1961, 1964, 1965).

Indirect dependence is illustrated by a number of organisms that are sessile-filter feeders, carnivores or scavengers. Sessile in-

Table II-23

Species List of the Common Kelp Bed Fauna for Southern California
and Northern Baja California. Modified from: Bright (1974)

Protozoa (single celled animals)

Gromia oviformis

Porifera (sponges)

Haliclona cinerea
Haliclona lunisimilis
Haliclona sp.
Rhabdodermella nuttingi
Tethya aurantia

Coelenterata

Hydrozoa (hydroids)

Plumularia setacea

Anthozoa (anemonies, corals)

Corynactis californica
Muricea californica
Muricea fruticosa

Bryozoa (moss animals)

Costazia robertsoniae
Hippothoa hyalina
Membranipora membranacea
Diaperoecia californica
Phidolopora labiata
Rhyncozoon rostratum
Thalamoporella californica

Mollusca (molluscs)

Gastropoda (snails, nudibranchs, sea slugs)

Aplysia californica
Astraea undosa
Conus californicus
Haliotis fulgens
Haliotis rufescens
Kelletia kelletii
Lacuna unifasciata
Mitrella carinata
Norrisia norrisii
Zonaria spadicea

Table II-23 (continued)

Pelecypoda (clams, mussels, oysters)

Chama pellucida
Hiatella arctica
Hinnites multirugosus
Leptopecten latiaurata
Penitella penita
Pseudochama exogyra

Annelida (segmented worms)

Oligochaeta

Polychaeta

Axiiothella sp.
Dexiospira spirillum
Eudistyla polymorpha
Eulalia macrocerus
Eusyllis sp.
Harmothoe sp.
Jasmineira sp.
Kefersteinia cirrata
Nicolea sp.
Phragmatopoma californica
Phyllodoce lineata
Platynereis bicanaliculata
Polyophthalmus sp.
Sabellaria cementarium
Syllis sp.

Arthropoda

Crustacea

Cirripedia (barnacles)
Balanus trigonus

Mysidacea (opossum shrimps)

Acanthomysis costata
Acanthomysis macropsis
Acanthomysis sculpta
Lycomysis sp.
Metamysidopsis elongata
Mysidopsis californica
Mysidopsis sp.
Neomysis rayi

Isopoda

Cirolana parva
Cyathura sp.

Table II-23 (continued)

Idothea resecata
Jaeropsis dubia
Janiralata occidentalis
Janiralata rajata
Limnoria algarum

Amphipoda

Acidostoma sp.
Ampithoe humeralis
Ampithoe rubricata
Corophium sp.
Elasmopus pocillimanus
Eusirus sp.
Iphiotus sp.
Maera hirondeilli
Photis californica
Podoceropsis kermadeci

Decapoda (crabs, shrimp, lobster)

Leptochelia sp.
Leptognathia sp.
Panulirus interruptus
Parapseudes sp.

Echinodermata

Asteroidea (starfish)

Dermasterias imbricata
Henricia leviuscula
Patiria miniata
Pisaster giganteus

Echinoidea (urchins, sand dollars)

Lytechinus anamesus
Strongylocentrotus franciscanus
Strongylocentrotus purpuratus

Ophiuroidea (brittle stars)

Ophiopteris papillosa
Ophiothrix spiculata

Holothuroidea (sea cucumbers)

Parastichopus parvimensis

vertebrates are frequent colonizers on the frond, stipe and holdfast of *Macrocystis* (Wing and Clendenning, 1959; Woollacott and North, 1971). The sea floor of a kelp bed, heavily shaded by the canopy, becomes overgrown with sessile animals, frequently several centimeters thick. Unlike the sessile fauna of kelp fronds, the bottom invertebrates have a more enduring substrate and longer-lived species are common. Most of these filter feeders are presumed to utilize microscopic organic detritus of kelp origin available to them in addition to phytoplankton. Prominent filter feeders in kelp beds include bryozoans, hydroids, crustaceans and sponges. Also usually present are pelecypods, gorgonian corals and polychaete worms. Common intermediate invertebrate carnivores are sea urchins, cephalopods, crustaceans, anthozoans, gastropods and polychaete worms. Top invertebrate carnivores include starfish, anthozoans and scyphozoans. There are a number of groups with scavenger and debris-feeding members, i.e., polychaetes, sea urchins, holothurians, anthozoans, crustaceans, gastropods and starfish.

An additional group of organisms has been found in or upon the holdfast portion of the kelp plant. This assemblage of "interstitial" organisms is not well understood and needs additional study (Ghelandi, 1971).

With continued use of kelp as a resource, parallel studies on associated benthic invertebrates will be essential. In point of fact, additional data are needed with regard to the food web within a kelp bed and how that web is affected by natural and man-made changes in the environment. (Pollution effects on kelp beds will be discussed

briefly later in this section and also in Section II.E.3.a.).

(7) Mainland Shelf

The early study on the benthos of the mainland shelf was a 1952 to 1954 study conducted in the San Pedro Basin and shelf (Hartman 1955, 1966). Jones (1969), summarized the papers generated from the Allan Hancock Foundation's 1956-1960 study of the mainland shelf from Point Conception to the Mexican Border. These papers include those by Barnard and Hartman (1959); Barnard, Hartman, and Jones (1959); Barnard and Ziesenhenné (1961); Given and Jones (1962); Jones (1967); and Jones and Barnard (1963). This study is also well summarized by Allan Hancock Foundation (1965). Numerous accounts are available on selected groups. Some of these include: benthic amphipods (Barnard, 1963); nematodes (Jones, 1964); brachiopods (Jones and Barnard, 1963); cumaceans (Barnard and Given, 1961); ophiuroids (Barnard and Ziesenhenné, 1961). In addition there are a number of general faunal lists associated with studies of certain geographical (natural or man-made) areas: Carlisle (1969); Emerson (1970); Fauchald (1970); Pequegnat (1964); State Water Resources Control Board (1971); Turner et al. (1964, 1966, 1968); Turner and Strachan (1969); Wintz and Fauchald (1970). Studies since the Allan Hancock study have been confined to more limited geographical locations and have concentrated on the effects of pollution on the benthic community.

The mainland shelf extends from shore to a depth of approximately 300 ft. (about 100 meters) and comprises 6.2% of the area from shore to the Patton Escarpment (Allan Hancock Foundation, 1965).

The average standing crop biomass of the benthic macrofauna was 356 grams/sq. meter, but was reduced to about 250 with the exclusion of the samples dominated by the worm *Listriolobus pelodes* off Santa Barbara. Emery (1960) reported the variation in the standing crop of the mainland shelf to be 40 - 4,000 grams per sq. meter. Sand, sandy-silt and silty-sand constituted some 80 percent of the soft sublittoral bottom off Southern California. In coarse sand, the larger organisms (macrofauna) number 2,500 organisms/sq m; in fine silts, this number may be about 5,000 organisms/sq m. The above values are based on the animals retained on a screen with mesh openings of 0.7mm - estimated to be 60 percent of the total macrofaunal specimens (Jones, 1969).

In detailed examination of 176 samples collected in the 1956-60 Allan Hancock Foundation survey, 1,473 different benthic invertebrates were identified, 63.5 percent of these were identified to species; 24.9 percent to genus, and 11.6 percent only to higher taxonomic categories. Polychaetes (segmented annelid worms) were the most widely distributed group, outranking any other group in species, numbers, and total weight. Nearly half (35%) of all specimens counted were polychaetes; 532 species were identified, and the average concentration was 1,424 organisms/sq m. Crustaceans, especially phoxocephalid amphipods, accounted for about 25 percent of all specimens but because of their small size, seldom comprized more than 5 percent of the biomass. They were the second largest group, with 419 species and a mean concentration of 1,352/sq m. Echinoderms (brittle stars, for example) form a major group on the shelf in depths greater than 10 meters. Within this group, 64 species, with an average concentration of 523 organisms/sq m, were identified. The

small red brittle star *Amphioda urtica* was the most abundant single species, being found in 85 percent of all samples at depths greater than 30 ft. (10 m), averaging 400 individuals per sq. meter. Molluscs (clams and snails) constituted the fourth group in order of abundance, with 408 species and an average concentration of 368 organisms/sq m. Bivalve molluscs were usually so small that they contributed only a small amount to the biomass, even though they were weighed with their shells. The Echiuroid worm *Listriolobus pelodes* were not widespread, but heavily concentrated in the fine sediment area near Santa Barbara. The Brachiopod *Glothidia albida* was found in 60 percent of the samples. The above groups accounted for over 90 percent of the benthic biomass, and the majority of the species that were collected. Table II-24 shows the size and weights of some of the large and common benthos of the mainland shelf.

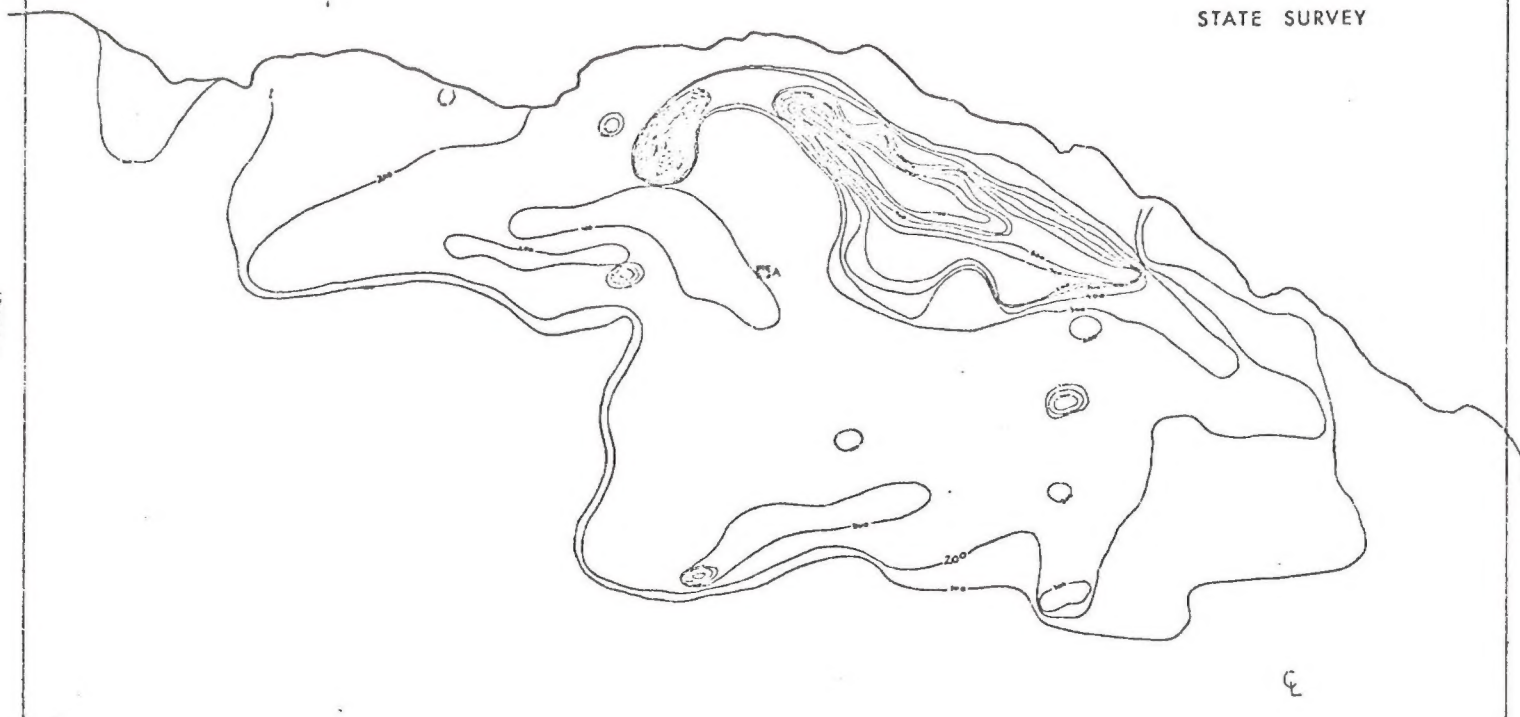
Near Santa Barbara the vast majority of specimens, both in numbers and biomass (80%), consisted of the echiuroid worm *Listriolobus pelodes*. This species remained dominant in 1969, (Fauchald, 1971) but was greatly reduced as compared to the late 1950's at the time of the Allan Hancock Foundation Study. This is evident in Fig. II- 39 (State Survey) and Fig. II-40 (Pollution Study).

Due to the multiplicity of habitats (sediment type, depth, slope of bottom, etc.) of the youthful Southern California shelf and the general difficulty of placing the benthos into neat biomes or associations as terrestrial ecologists have been able to do, generalizations about benthic communities are difficult to make. Hartman (1955a, 1966), in her study of the San Pedro Bay Shelf, was particularly impressed by the

STANDING CROP
OF
MACROINVERTEBRATES

STATE SURVEY

PLC



6

Figure II-39
From: Fauchald (1971)

Distribution of the standing crop of macro-invertebrates off Santa Barbara during the State Survey. The isopleths are in 100 grams per square meter intervals.

Table II-24 From: Allan Hancock Foundation (1965)

WEIGHTS AND SIZES OF SOME OF THE LARGE AND COMMON ANIMALS OF THE COASTAL SHELF OF SOUTHERN CALIFORNIA (FOLLOWING THIS TABULATION IS A LIST OF OTHER ANIMALS FOR WHICH SIZE DATA HAVE NOT BEEN COLLECTED COMPLETELY)

Name	Common Name	Number Measured	Length mm		Width mm	
			Range	Mean	Range	Mean
<i>Halopoda intermedia</i>	holothurian	14	40-90	61	4.7-58.6	22.8
<i>Salpa sicaria</i>	razor clam	10	40-87	62	1.5-23.7	9.9
<i>Listriolechus pilodis</i>	tongue worm	322	8-45	26	0.2-19.6	8.0
<i>Brissopsis pacifica</i>	urchin	5	22-44	35	2.4-12.8	6.8
<i>Glycera robusta</i>	proboscis worm	9	47-240	143	1.5-12.0	6.5
<i>Salpina</i> sp.	clam	6	25-38		1.7-8.7	5.7
<i>Polinices</i> sp.	moon snail	18	8-42	18	0.3-27.2	5.5
<i>Cerithiulus</i> sp.	nemertean	7	65-180	127	1.3-8.0	3.9
<i>Astropectes californicus</i>	starfish	27	25-170	57	0.5-22.3	3.8
<i>Travisia</i> pupa	polychaete	20	14-50	35	0.4-8.0	3.6
<i>Glycera americana</i>	proboscis worm	7	80-175	124	1.4-5.2	3.4
<i>Lytechinus anamesus</i>	urchin	15	0-32	19	0.5-11.2	2.9
<i>Conus californicus</i>	cone snail	8	14-29	23	0.6-5.1	2.9
<i>Schizocardium</i> sp.	acorn worm	6	50-90	69	1.6-4.0	2.7
<i>Cerianthids</i>	anemones	7	37-72	51	0.14-7.50	1.9
<i>Asychis laceria</i>	bamboo worm	6	47-125	78	0.4-3.9	1.6
<i>Chaetopterus variopedatus</i>	parchment worm	275	30-90			
<i>Stylatula</i> sp.	sea whip	5	170-520	384	0.2-3.0	1.4
<i>Pherusa capulata</i>	polychaete	11	25-110	61	-- --	--
<i>Yoldia cusifera</i>	clam	11	23-38	29	-- --	--
<i>Dendrostroma</i> sp.	peanut-worm	23	18-50	33	-- --	--
<i>Pista disjuncta</i>	polychaete	7	41-100	67	-- --	--
<i>Lima delisensis</i>	clam	109	15-30		-- --	--
<i>Nassarius perpinianis</i>	snail	8	13-21	17	-- --	--
<i>Diapatra ornata</i>	polychaete	7	37-68	51	-- --	--
<i>Cardita ventricosa</i>	clam	203	3-18		-- --	--
<i>Pectinaria californiensis</i>	cone worm	16	16-36	22	-- --	--
<i>Chloca pinnata</i>	sting worm	100	10-17		-- --	--
<i>Dentalium rectius</i>	tooth-shell	53	30-40		-- --	--

Additional Large and Common Species of Animals for Which Only Scanty Weight Data Are Available

Adults weighing more than 100 grams

<i>Allocentrotus fragilis</i>	urchin
<i>Stichopus</i> sp.	holothurian

<i>Dendroster</i> sp.	sand dollar
<i>Nephtys assignis</i>	polychaete

Adults weighing more than 1 gram

Adults weighing more than 50 grams

<i>Spolargus californicus</i>	urchin
<i>Asterina miniata</i>	starfish

<i>Amphiodia occidentalis</i>	ophiroid
<i>Ophiopsila californica</i>	ophiroid
<i>Ophiotrichis spiculata</i>	ophiroid
<i>Leptosynapta albicans</i>	holothurian
<i>Pentamure pseudopopulifera</i>	holothurian
<i>Callinassa</i> sp.	ghost shrimp
<i>Heteronereis</i> sp.	crab
<i>Gari, californica</i>	clam
<i>Pandora punctata</i>	clam
<i>Periploca discus</i>	clam
<i>Asychis disparidentata</i>	bamboo worm
<i>Lumbrineris</i> spp.	polychaete
<i>Nephtys</i> spp.	polychaete
<i>Nothria</i> spp.	polychaete
<i>Notomastus magnus</i>	polychaete
<i>Sternaspis fassor</i>	polychaete
<i>Murphysa</i> sp.	polychaete
<i>Eunice americana</i>	polychaete
<i>Pseudopotentilla</i> sp.	polychaete
<i>Stenobasis</i> sp.	polychaete
<i>Praxillella</i> sp.	polychaete
<i>Ethenalis</i> sp.	polychaete
<i>Nephtys ferruginea</i>	polychaete

Adults weighing more than 10 grams

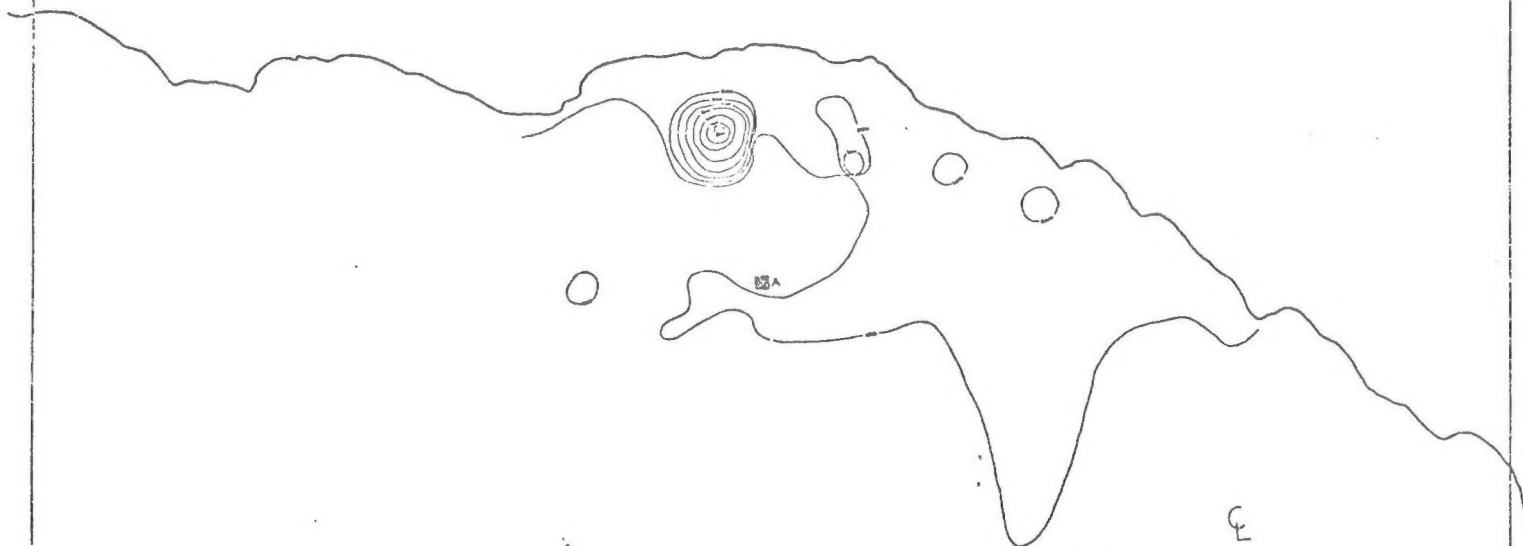
<i>Mediaster acqualis</i>	starfish
<i>Brisaster toussendi</i>	urchin
<i>Strongylocentrotus purpuratus</i>	urchin
<i>Lorenia cardiformis</i>	urchin
<i>Bl. pharipoda occidentalis</i>	spiny sand crab
<i>Macoma nasuta</i>	clam
<i>Eupagurus</i> sp.	hermit crab

Adults weighing more than 5 grams

<i>Ophionereis curvirostris</i>	ophiroid
<i>Japon festinus</i>	snail
<i>Megasturcula carpenteriana</i>	snail
<i>Sipium</i> sp.	snail
<i>Tellina ilae</i>	clam
<i>Aphroggata</i> sp.	sea mouse
<i>Sipunculus nudus</i>	sipunculid
<i>Florammina perpleura</i>	crinoid

STANDING CROP
OF
MACROINVERTEBRATES

POLLUTION STUDY



Distribution of the standing crop of macroinvertebrates off Santa Barbara during the Pollution Study. The isopleths are in 100 grams per square meter intervals.

Figure II-40

From: Fauchald (1971)

patchy distribution of the benthic fauna. Indeed, "patchiness" has become an integral part of her interpretation of the character of the fauna of the mainland shelf of Southern California. It is her conclusion that "specific diversity in Southern California is so characteristic that large-scale communities of organisms cannot be identified." (Hartman, 1966, p. 190). She makes exception only for the *Listriolobus* association of the Santa Barbara Shelf.

In spite of the difficulty, a determination of associations (termed "communities") on the mainland shelf was made by Dr. J. Laurens Barnard of the Allan Hancock Foundation Survey Staff.

Barnard's methods were summarized by Jones (1969). At first he attempted to follow the system outlined by Thorson (1957), but abandoned it as unworkable. Instead, he utilized a system whereby the "dominant animals", for which the associations are named, were determined on the basis of their standing crop ranks. "All samples allocated to a community must have the appropriate animals dominating it in the upper ranks of 1 to 4" (Barnard, unpubl. report).. The system is partially subjective in that it allows a choice among the first four ranks. Unlike Thorson's method, Barnard's required that a sample fit the required criterion to represent an association; those samples that did not were labeled "no dominant." Some of the associations derived by this method were identified by two "dominant animals" ("co-dominants"). The distributions of these associations, differing in some details from the associations described by the Allan Hancock Foundation, were mapped on the basis of this analysis. The major associations are shown on Figs.II-41 to 44 and are described below (Allan Hancock Foundation (1965).

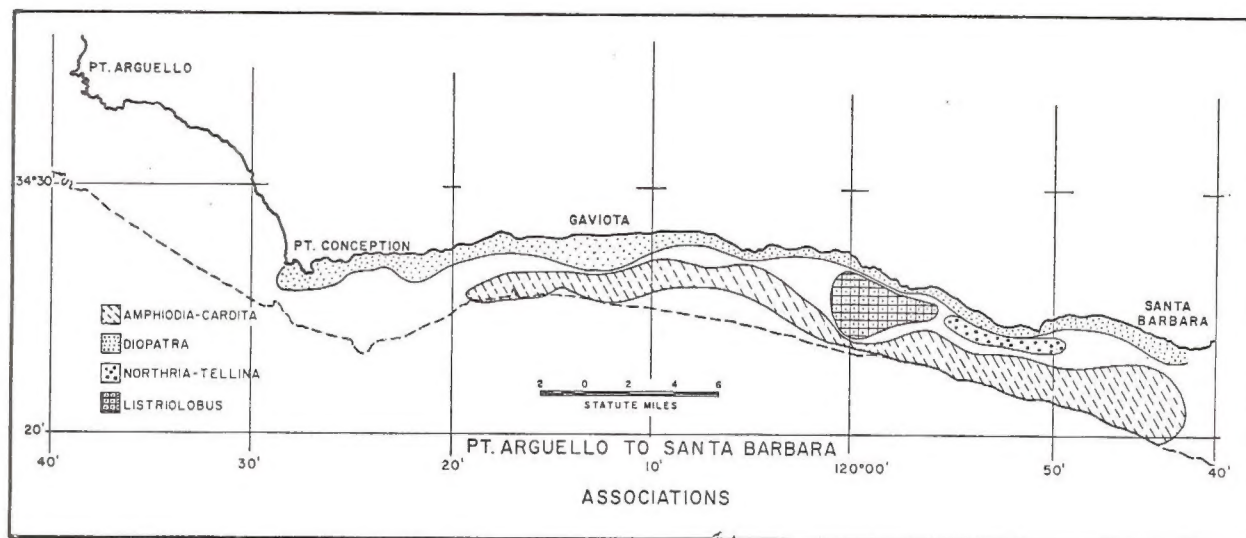


FIGURE II-41 From: Jones (1969)
The Distribution of Benthic Macrofaunal Associations on the Mainland Shelf, Point Arguello (Point Conception) to Santa Barbara (Based on an unpubl. fig. by Barnard). Note: Only the major (widely distributed) associations are mapped.

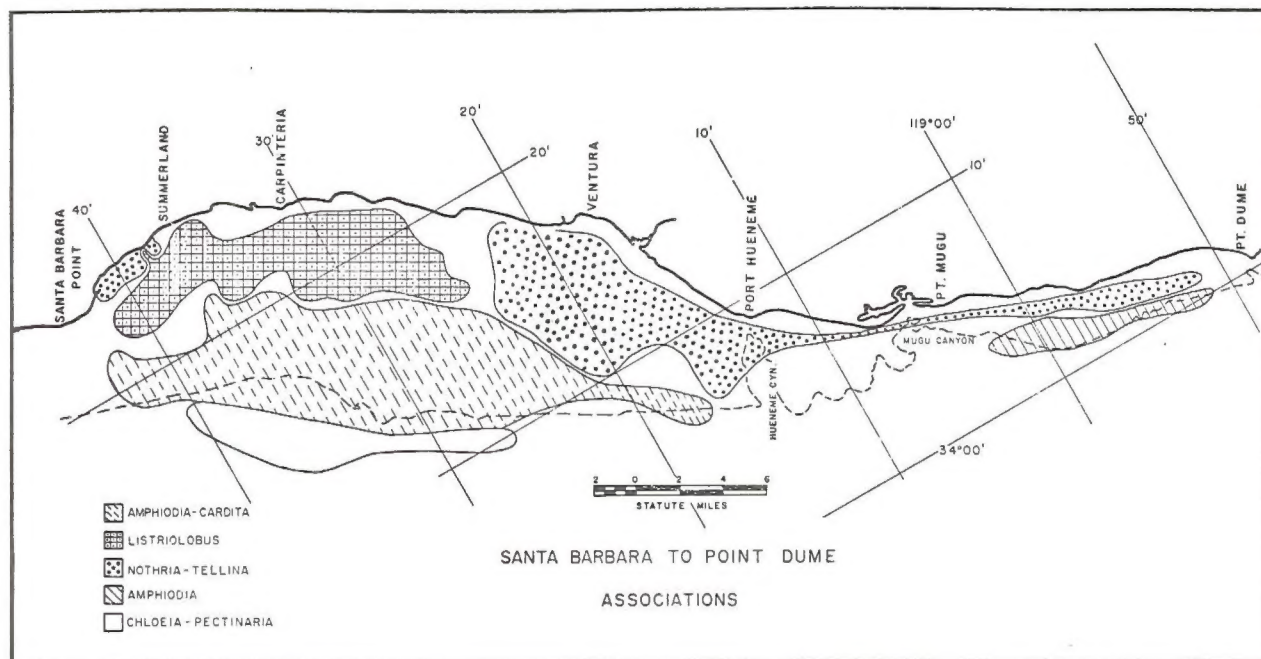


FIGURE II-42 From: Jones (1969)
The Distribution of Benthic Macrofaunal Associations on the Mainland Shelf, Santa Barbara to Point Dume (Based on an unpubl. fig. by Barnard). Note: Only the major (widely distributed) associations are mapped.

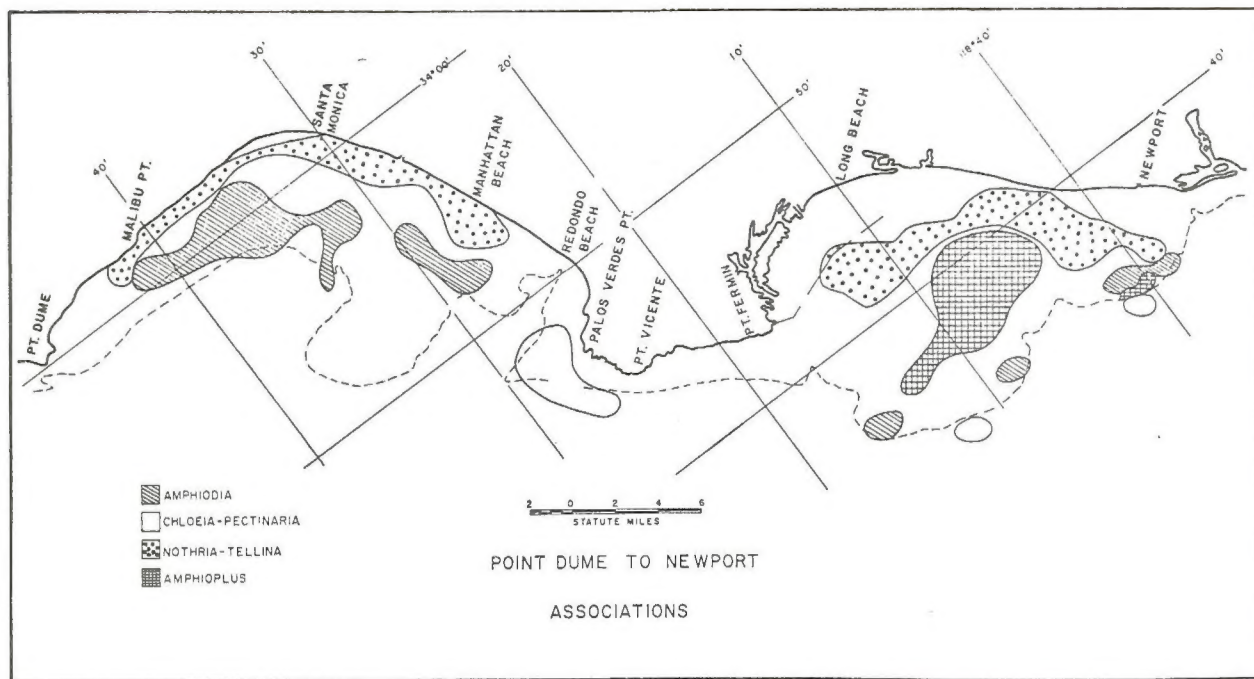


FIGURE II-43 From: Jones (1969)
The Distribution of Benthic Macrofaunal Associations on the Mainland Shelf, Point Dume to Newport (Based on an unpubl. fig. by Barnard). Note: Only the major (widely distributed) associations are mapped.

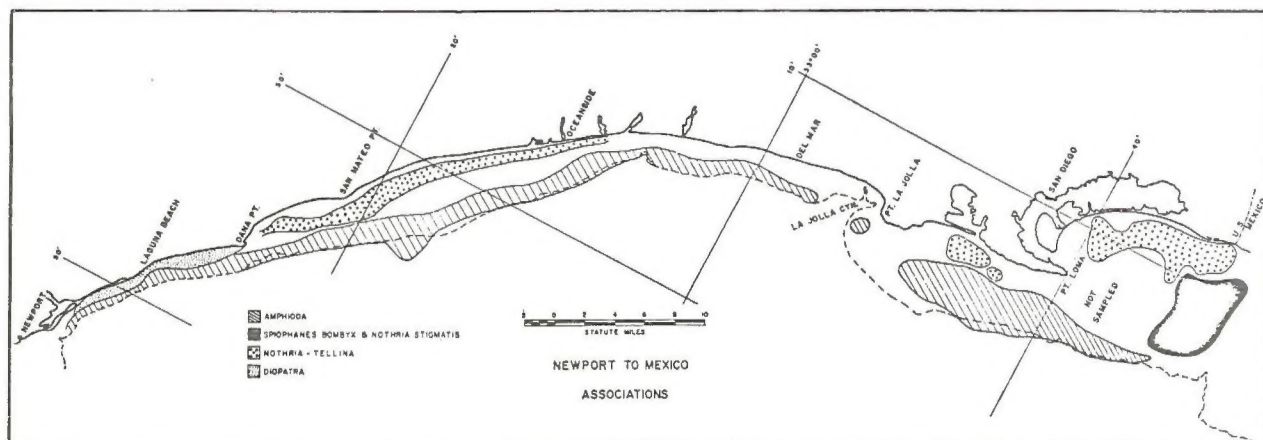


FIGURE II-44 From: Jones (1969)
The Distribution of Benthic Macrofaunal Associations on the Mainland Shelf, Newport to Mexico (Based on an unpubl. fig. by Barnard). Note: Only the major (widely distributed) associations are mapped.

1. *Listriolobus* - The tongue worm *Listriolobus pelodes*, accounted for 80 percent of the biomass of this community off Santa Barbara. Although it occurs sporadically along the Southern California shelf it reaches large numbers only near Santa Barbara.

2. *Amphiodia* - The ophiuroid (brittle star) *Amphiodia urtica* was found in 85 percent of the samples, under a wide range of conditions. It became dominant on soft bottoms at depths between 40 and 100 m., especially south of Ventura. Its limitations appear to be imposed by physical factors including small size of sedimentable food particles and such biological factors as lack of successful competition by other animals.

3. *Amphiodia-Cardita* - The brittle star *Amphiodia urtica* and the clam *Cardita ventricosa* community occurs on the Santa Barbara shelf below the *Listriolobus* community from about 60 to 100 m. This community is not found in the southern part of the area because *Cardita* is infrequent south of Ventura.

4. *Chaetopterus* - The polychaete parchment worm *Chaetopterus variopedatus* forms a distinctive community off San Pedro Hills in black mixed muddy bottoms close to shore in depths of 12 to 40 m. where food content is high and where relatively strong currents prevail. It flourishes under these conditions, with thickly massed tubes overlying the substrate. It is always associated with a highly diversified fauna of predictable kinds. Similar large concentrations of *Chaetopterus* occur at a few other places, including Bechers Cove on Santa Rosa Island, Howlands Landing on the leeward side of Santa Catalina Island, and off East End at the tip of this island. The associated

organisms differ according to locality. At Whites Point it is a clam, *Lima dehiscens*. At Bechers Cove it is a polychaete, *Myxicola infundibulum*, and at Howlands Landing it is *Owenia* and other kinds of chaetopterid polychaetes. In Newport Bay *Chaetopterus* fouls the bottoms of floats and boats which have been undisturbed for a year or more (MacGinitie, 1938, p. 209).

5. *Pista-Nothria* - The polychaetous worms *Pista disjuncta* and *Nothria pallida* form a community in many green muds in moderate depths, near the edge of the shelf or on the deeper slopes. It occurs especially in the vicinities of submarine canyons.

6. *Onuphis* - The polychaete *Onuphis* sp, community occurs on bottoms of coarse sand. As sediment grain size decreases this community grades into and is replaced by the *Amphiodia urtica* community.

7. *Blepharipoda-Branchiostoma* - The spiny sand crab *Blepharipoda occidentalis* and the cephalochordate *Branchiostoma californiensis* (known to biology students as amphioxus) form a sharply limited community where red or brown sands occur. The associated organisms are more sharply limited than in any of the other communities, since they are often kinds of animals not found elsewhere. They include: *Ampelisca cristata*, an amphipod; *Sipunculus nudus*, a sipunculid; *Dendraster excentricus*, the common sand dollar; and seven species of polychaetes not present in other areas.

8. *Diopatra* - The polychaete *Diopatra ornata* was found in greatest concentrations in shallow areas along the entire coast and was best established where kelp and rocky bottoms occur. At maximum development the tubes measure more than 12 inches long, being matted or

massed over the surface. Where algae abound it is commonly found with a nest-building nereid, *Platynereis bicanaliculata*.

9. Slope Communities (67 to 200 m) - Three assemblages of broad distribution were delineated in this environment.

- 1) Dominated by *Amphiacantha amphacantha*, a large brittle star.
- 2) Dominated by *Amphiodia digitata*, a large brittle star.
- 3) *Chloeia* sp, (stinging worm) *Pectinaria* (cone worm), both polychaetes.

These are areas where the large sea urchins *Briaster* and *Brissopsis* comprise a considerable proportion of standing crop so that slope communities maintain as high a standing crop as communities in shelf waters (10-67 m). Nevertheless, the small amount of existing organic matter in sea urchins and the probability that they grow slowly and have a low turnover are factors of importance in comparing raw data of standing crop between shelf and slope.

10. Rocky Bottoms - Several rocky bottom communities might be identified, but rocky outcrops are relatively sparse and difficult to sample with the gear used. Most animals are epifaunal, either attached to the rocks, or existing in crevices. Representative species are a seastar, *Asterina*, a large snail, *Astraea undosa*, a surface brittle-star, *Ophiothrix spiculata*, a stalked barnacle, *Scalpellum*, and other animals. Rocky bottoms were discussed further above.

11. Some Small Communities - Possibly the following communities are recognizable, but they are of small extent in Southern California. Most of them have been recovered in less than five samples, but they appear to be distinct types of assemblages.

- (a) *Dendraster* sp. The sand dollar community in sands in shallow water. May be mixed with *Chaetopterus*.
- (b) *Ophiura lutkeni*. A deep water ophiuroid brittle star assemblage.
- (c) *Ampelisca*. A deep water gravel community dominated by this tube-building amphipod.
- (d) *Pherusa-Onuphis*. A dominant complex recovered in three samples around the Whites Point outfall to a near exclusion of other animal species. Both animals are polychaetes.
- (e) *Capitella*. This polychaete, reported as an indicator of diluted sea-water and also of polluted areas in enclosed bays and harbors, dominated several samples. Two or three of the samples were probably indicative of natural pollution as a result of the metabolic activities of other epifaunal animals, whose fecal matter falls to the bottom and provides a rich organic mud. This is especially the condition in beds of *Diopatra* in kelp and algal fields.
- (f) *Tharyx*. The tube-building worm *Tharyx tessellata* dominated a number of samples on the San Pedro Shelf just off the breakwater. It might be considered an indicator of low levels of pollution, either man-made or natural, because the animal also dominates other samples where naturally produced dark gray or black sediments occur. Reish (1959) considered *Tharyx parvus* an indicator of

"healthy bottom" in Los Angeles Harbor. Notwithstanding some of the muds it occupied were black and, for open sea areas, this is most certainly indicative of an oversupply of organic matter. Species of *Tharyx* were widespread and numerous through about 15 percent of the total samples taken, and their presence alone is not an indicator of pollution. "Perhaps the numerical frequency in relation to surrounding samples may be of some use in pinpointing degrees of pollution."

On the basis of the samples spaced statistically according to area, an estimate has been made of the areas occupied by some of the principal communities, with results as shown on Table II-25.

The method of classifying benthic communities based upon a dominant species, reported above, emphasizes distinctiveness at the expense of similarities. Widely distributed species were sometimes omitted from the descriptions. Small but numerically abundant forms, particularly polychaetes and amphipods, tend to be omitted from the descriptions of these associations (Jones, 1969). Jones reported that relatively few of the species collected in the Hancock Foundation shelf survey were both frequent (found in 40 percent or more of the 176 samples) and reasonably numerous (15 or more specimens/sq. m). Table II-26 lists the 24 species that might be designated "prevalent", in terms of their frequency of occurrence and population density. These 24 species (and the four other groups listed in the table) comprised only 1.6 percent of the total macroinvertebrate species found on the mainland shelf. Nevertheless, because they are nearly ubiquitous, relatively abundant, and found frequently with a number of other species, these organisms may be considered the major faunal elements on

Table II-25 From: Allan Hancock Foundation (1965)

**DOMINANCE OF BENTHIC COMMUNITIES ON THE SOUTHERN
CALIFORNIA MAINLAND SHELF. SPACED STATISTICALLY
ACCORDING TO AREA, BASED ON 150 STATIONS**

	<i>Per cent of total shelf area</i>
<i>Amphiodia</i>	23
<i>Listriolobus</i>	7
<i>Onuphis</i>	6
<i>Amphiodia/Pectinaria</i>	5
<i>Nothria</i> spp.	5
<i>Amphiodia/Cardita</i>	4
<i>Diopatra</i>	4
<i>Cardita</i>	3
<i>Astropecten</i>	1
<i>Chlodia</i>	1
<i>Chaetopterus/Lima</i>	1
<i>Sternaspis</i>	1
<i>Amphiodia/Onuphis</i>	1
<i>Lytechinus</i>	1
<i>Tharyx</i>	1
Diversified and unclassified	67
TOTALS	100

284

Table II-26
COMMON BENTHIC INVERTEBRATES IN THE SOUTHERN
CALIFORNIA MAINLAND SHELF*

Species	Frequency of Occurrence (percent)	Density (no./sq m)	Density Rank
POLYCHAETES			
<i>Prionospio pinnata</i>	90.4	28.0	
<i>Prionospio malmgreni</i>	84.5	92.8	2
<i>Pectinaria californiensis</i>	74.5	45.3	9
<i>Pholoë glabra</i>	71.1	51.1	5
<i>Paraonis gracilis</i>	61.3	48.3	6
<i>Spionophanes missionensis</i>	60.8	22.8	
<i>Tharyx tessellata</i>	59.7	53.6	4
<i>Haploscoloplos elongatus</i>	59.7	31.7	
<i>Sternaspis fossor</i>	54.0	15.7	
<i>Glycera capitata</i>	53.3	17.6	
<i>Lumbrineris cruzensis</i>	52.3	35.9	
<i>Cossura candida</i>	51.7	45.8	8
<i>Nephtys</i> sp.	51.2	24.2	
<i>Aricidea lopezi</i>	45.5	28.7	
CRUSTACEANS			
Ostracods unknown	61.9	279.9	**
Tanaids unknown	59.7	26.3	
<i>Ampelisca brevisimulata</i>	57.4	35.7	
<i>Heterophoxus oculatus</i>	55.0	23.8	
<i>Ampelisca cristata</i>	50.5	22.9	
<i>Paraphoxus bicuspidatus</i>	43.8	47.6	7
<i>Paraphoxus similis</i>	43.2	17.4	
<i>Metaphoxus frequens</i>	41.5	18.0	
ECHINODERMS			
<i>Amphiodia urtica</i>	87.0	359.1	1
<i>Amphipholis squamata</i>	77.3	39.5	10
MOLLUSCS			
<i>Axinopsida serricata</i>	52.3	54.7	3
OTHER TAXA			
Nemerteans unknown	100.0	28.0	
Nematodes unknown	51.7	27.2	
<i>Glottidia albida</i>	51.7	24.2	

*From Jones (1967, 1969)

**Not ranked (comprises several species).

the mainland shelf.

The diagrammatic representation of the inhabitants of a typical one-quarter square meter of bottom soil in the *Listriolobus* association presented by Barnard and Hartman (1959) did not include six species which these authors considered prominent members of this association. These are *Ceratocephala c. americana* (mean density, $76/m^2$), *Marphysa* sp. ($40/m^2$), *Hesperonoe* sp. ($56/m^2$), *Sternaspis fossor* ($16/m^2$), *Amphiodia urtica* ($98/m^2$) and *Saxicavella pacifica* ($93/m^2$). Together they represent a population of 370 specimens per square meter. The omission of *Amphiodia urtica* is particularly noteworthy. The mean density of *Amphiodia urtica*, $98/m^2$, is nearly a fourth of that in the *Amphiodia-Cardita* association ($408/m^2$) and almost one-half that in the *Amphioplus hexacanthus* association. The presence of important species such as this should not be obscured in the process of faunal description.

To explore faunal similarities further Jones utilized a system developed by Fager (1957; Fager and McGowan, 1963) for the determination and analysis of recurrent groups based on the co-occurrences of species within a sample set. Application of this method is predicated on the rationale that species which are frequently part of each other's environment, e.g., 50 percent of the time, constitute appropriate ecological units.

The top 200 species as ranked by frequency in the 176-sample set were analyzed by the recurrent group method. Only 48 species showed affinity with other species when the affinity index was set at 0.650; these included 23 polychaetes, 18 crustaceans, two echinoderms, two mollusks and three from other phyletic groups. All of the 24 prevalent species listed in Table II-26 are included among these 48 species.

Twenty-eight of these species could be arranged in seven groups; the remaining 20 species had affinities with some, but not all, of the members of one or the other of these groups.

The distribution of the recurrent groups for three areas of the mainland shelf are shown on Figs. II-41 through II-44. Jones concluded that;

The general composition of groups obtained in this analysis strongly suggests that the recurrent groups are primarily subdivisions of the predominant fauna of the entire shelf. When applied to a small sample set (176 samples) representing a relatively large and heterogeneous area, the groups derived will include that part of the fauna most constant over the majority of the study area. Consequently, specific areas of faunal discontinuity escape recognition. Their faunal elements are too infrequent in the majority of samples to rate recognition (i.e., they lack affinities with the more generally distributed species). The classically defined *Listriolobus* association is a case in point. *Listriolobus pelodes* has no affinities with any other of the 200 species considered in this analysis, and therefore is not a member of any recurrent group.

No direct correspondence was found between the recurrent groups and the classically defined associations shown on Figs. II-45, through II-47. By narrowing the analysis of the method to a smaller area the recurrent groups more nearly approximate the major classical associations.

SCCWRP (1973) applied Fager's recurrent group concept to the polychaetes near the Whites Point sewage outfall off Palos Verdes. According to Jones the benthos of this area consisted of recurrent group IV (the polychaetes *Cossura candida* and *Sternaspis fessor*, Fig. II-46.. There were four recurrent groups according to SCCWRP (Table II-27, none of which are the members of group IV reported by Jones for this area. The distribution of the Palos Verdes recurrent groups is shown on Fig. II-48.

SCCWRP (1973b) felt they needed a more effective technique for converting the complex biological data from the Palos Verdes area into a more understandable form. Dr. W. G. Stephenson and Bob Smith applied

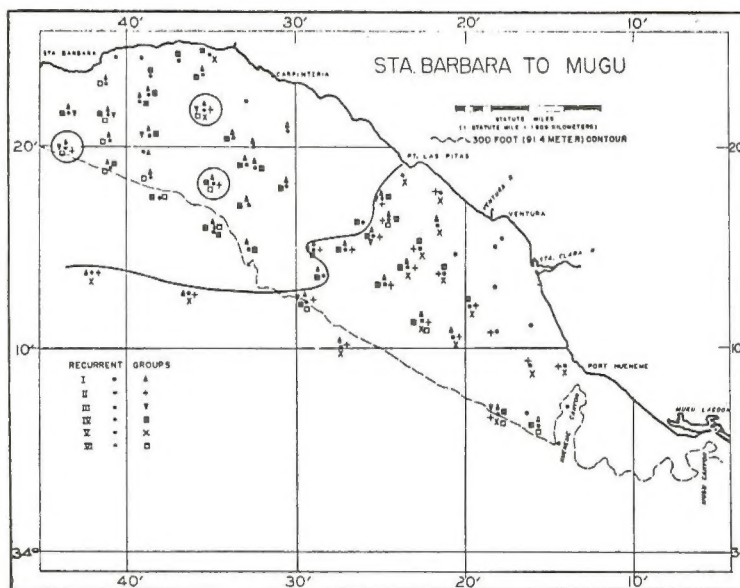


FIGURE II-45 From: Jones (1969)

The Geographic Distribution of the Recurrent Groups of the Mainland Shelf on the Santa Barbara Shelf (Santa Barbara to Mugu).

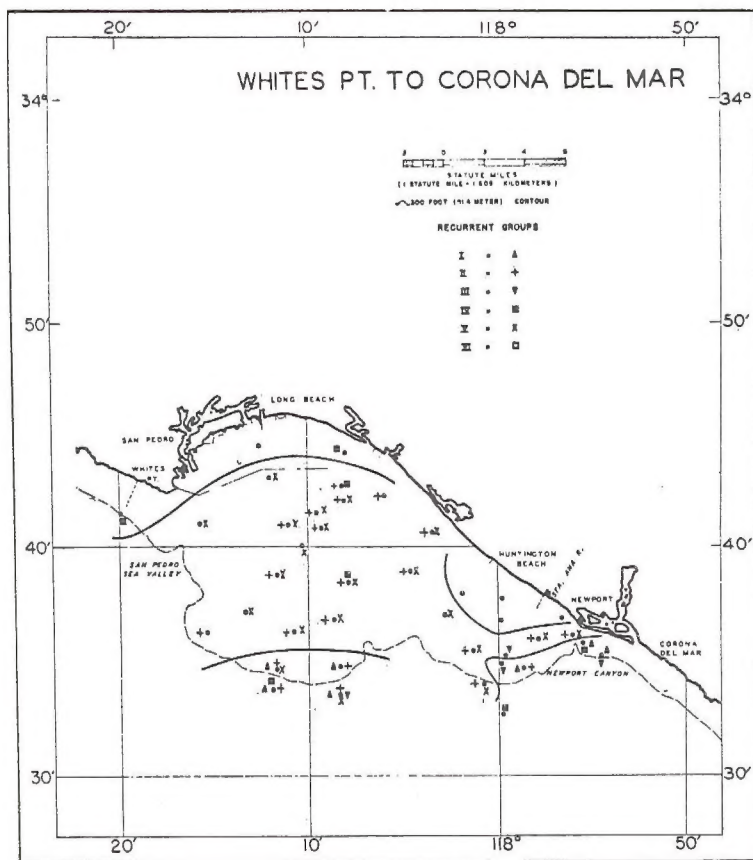


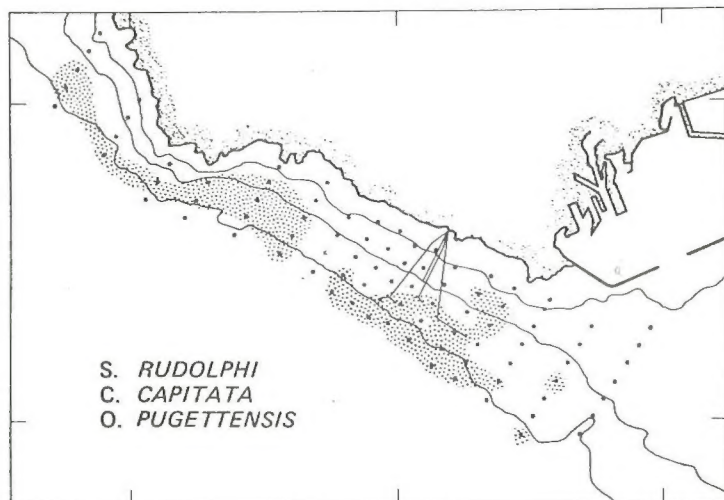
FIGURE II-46 From: Jones (1969)

The Geographic Distribution of the Recurrent Groups of the Mainland Shelf on the San Pedro Bay Shelf (Whites Point to Corona del Mar).

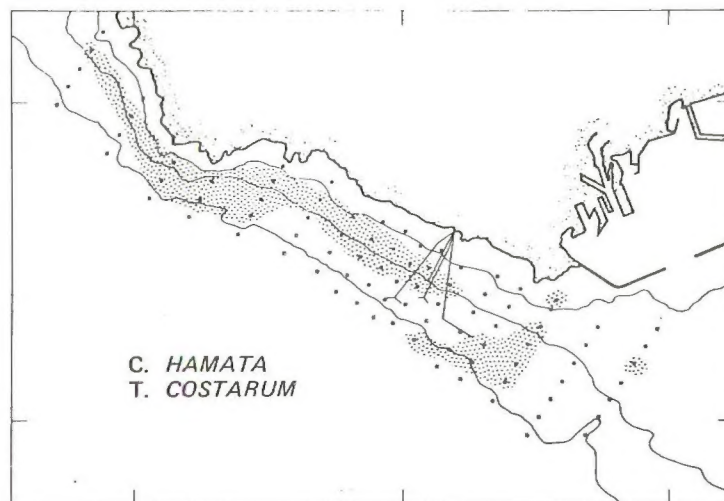
Table II-27

Polychaete Recurrent Groups Off Palos Verdes, July, 1971
From: SCCWRP (1973b)

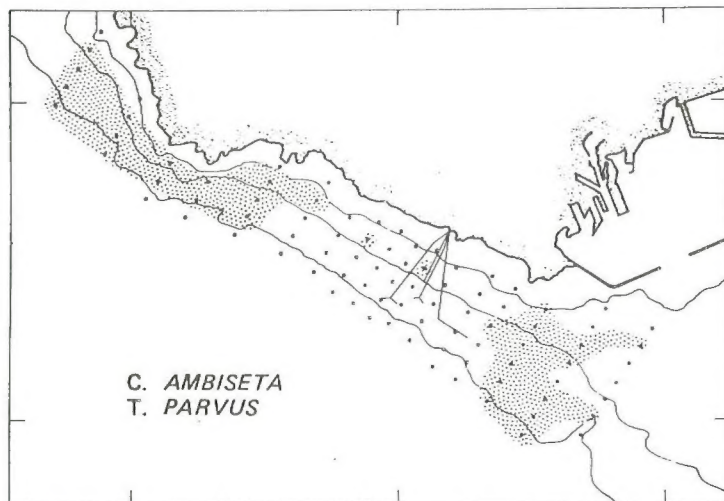
Group 1	<i>Stauronereis rudolphi</i> <i>Capitella capitata</i> <i>Ophiodromus pugettensis</i>
Group 2	<i>Caulleriella hamata</i> <i>Telepsavus costarum</i>
Group 3	<i>Capitita ambiseta</i> <i>Tharyx parvus</i>
Group 4	<i>Spiophanes fimbriata</i> <i>Notomastus tenuis</i>



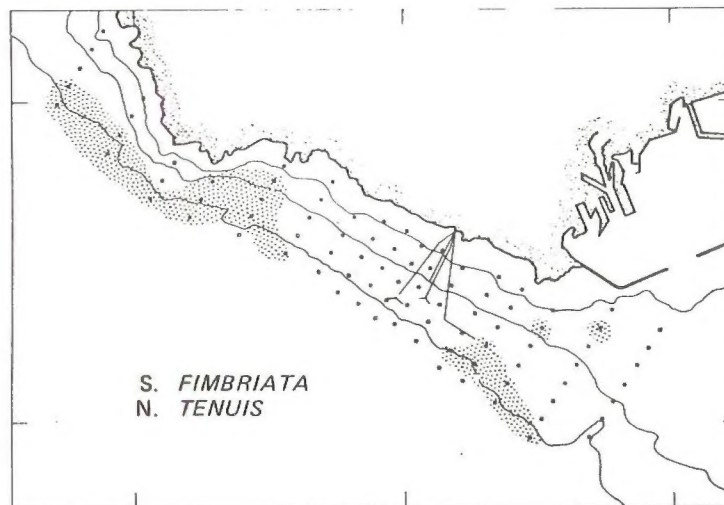
a. Group 1



b. Group 2



c. Group 3



d. Group 4

Fig. II-48. Distributions of Four Polychaete Species Groups Off Palos Verdes, July 1971.

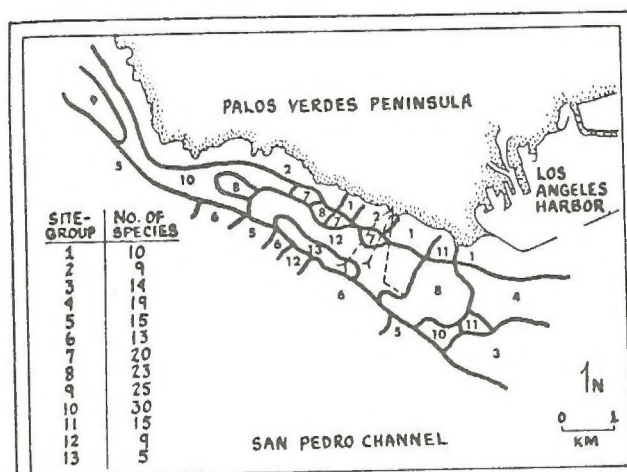
a site-group analysis based on both similarity of species composition and abundance of individuals per species. The distribution of the 13 site-groups (Fig. II-49) reflected the variation of the sediment physical and chemical parameters of the same area. Benthic pollution studies on the mainland shelf are discussed below.

Depths of 3 to 10 meters-According to Allan Hancock Foundation (1965), depths of 10 to 30 feet in sandy areas are relatively harsh environments due to an unstable bottom which shifts due to wave action. The number of individuals were not greatly reduced in comparison with the deeper bottoms, however. The types that have adapted to the shifting sands include those that occupy transient or relatively permanent deep burrows, as the long-neck clams, or that can burrow quickly, as the sand crabs (*Blepharipoda*), or that construct flexible tubes, as *Loimia medusa*, or that are spindle-shaped as the lancelet *Branchiotoma*, the polychaetes *Ophelia* and *Nephtys*, and *Sipunculus*, a peanut worm.

Polychaetes. The abundance of polychaete worms did not appear to be less than on deeper, siltier bottoms. Usually the inshore sand bottom fauna was dominated by 3 species : *Prionospio malmgreni*; *Nephtys caecoides* and *Goniada littorea*.

Nematodes were very abundant off Santa Barbara, Carpinteria, and south of San Diego.

Crustaceans. Crustaceans were greatly decreased in number of specimens in comparison with offshore bottoms. The reduction was on the order of 4.4 times (1,350 sq. meter offshore vs. 310 sq. meter inshore using a smaller sieving screen). The most abundant species were



The distributions of 13 site-groups of benthic invertebrates around the Whites Point outfalls

Fig. II-49 From: SCCWRP (1973b)

Diastylopsis tenuis, *Paraphoxus epistomus*, *Mandibalophous uncirostratus*, and *Paraphoxus bicuspidatus*.

Mollusks. Mollusks also decreased in frequency of specimens from an average of 470/sq. meter on offshore bottoms to an average of 180/sq. meter nearer shore. The most abundant was the small clam, *Tellina buttoni* and was considered an important co-dominant with the polychaete *Prionospio malmgreni*.

Echinoderms. Echinoderms were also greatly reduced in comparison with the offshore areas. Nearly half of the samples analyzed lacked echinoderms. The most abundant species was the sand dollar *Dendraster excentricus* which was the dominant animal off Huntington Beach, Ocean-side and San Diego.

(8) Submarine Canyons

The canyons extending from the coastline to the deep basins contain unique and varied fauna (Hartman, 1963 and Fay, 1972). Canyon habitats are subject to considerable fluctuations in environmental conditions because they serve as natural channels for shoreward movements of upwelling waters and organisms and for downward transport of runoff, sand, and debris. These processes result in widely varying (spontaneous) conditions, to which the indigenous organisms must adjust. In general, the variety and number of animals in canyons decrease with depth, as on the shelf in general. Relative composition and estimated mean biomass of canyon invertebrates are shown in Tables II-28 and II-29 (SCCWRP, 1973).

Table II-28
RELATIVE COMPOSITION OF CANYON INVERTEBRATES*

Canyon	No. of Samples	Percent of Identified Species					No. of Species Identified
		Poly- chaetes	Crusta- ceans	Molluscs	Echino- derms	Others	
Hueneme	14	56.6	14.5	14.5	4.4	10.1	159
Mugu	10	47.1	28.1	12.8	5.8	6.2	242
Dume	10	58.2	17.6	13.2	6.6	4.4	91
Santa Monica	15	69.4	8.2	9.4	6.5	6.5	170
Redondo	13	63.1	7.7	18.4	5.9	4.8	168
San Pedro Sea Valley	15	67.9	5.2	11.8	8.0	7.1	212
Newport	16	56.9	14.5	16.4	5.3	6.9	262
Mean		59.9	13.7	13.8	6.1	6.6	(149)

* From SCCWRP (1973)

Table II-29
ESTIMATED MEAN BIOMASS (g/Sq M) IN CANYON SAMPLES*

Canyon	Biomass (g/Sq M)
Hueneme	275
Mugu	154
Dume	145
Santa Monica	43
Redondo	367
San Pedro Sea Valley	88
Newport	151
Mean	175
*From SCCWRP (1973)	

(9) Basins

The names, general physical and hydrological features of the 13 basins have been well described by Emery (1960) and Hartman and Barnard (1960). The three along shore (San Pedro, Santa Monica, and Santa Barbara Basins) are the shallowest and are more or less completely known from quantitative bottom samples and photographs (Hartman and Barnard, 1958; Barnard and Hartman 1960; SCCWRP, 1973). The remaining basins are not well known, however, there are a number of general accounts: Hartman and Barnard (1958); Allan Hancock Foundation (1965); Emery (1960). Much collected material is yet to be published, principally associated with the activities of the R/V VELERO IV (University of Southern California), R/V SWAM (University of California, Santa Barbara), and various Scripps vessels (University of California, San Diego).

Faunal assemblages within the basins are classified as impoverished and populated. The three shallow basins have impoverished areas which cover a high percentage of their floors below sill depth (Hartman, 1955 a,b; Hartman and Barnard, 1958). This impoverishment is associated with reduced oxygen levels.

The second kind of basin, with more heavily populated floors, is illustrated by Santa Catalina, Santa Cruz, San Nicolas, Tanner, West Cortes and San Clemente Basins. Photographs reveal an abundance of polychaete worms, ophuroids, holothurians, crinoids, brachiopods, urchins and sea whips. Many species are endemic, perhaps due to the physical isolation of the respective basins.

Data obtained from 149 samples taken between 1952 and 1959 (Hartman and Barnard, 1958, 1960) are shown in Table II-30 and Table II-31. These data show that the number of species and the population density were far lower in all of the basins than on the mainland shelf. The outer basins had faunas that were distinctively different from those of the nearshore basins.

Table II-32 and II-33 provide a means of comparison of shelf and basin fauna. Table II-32 shows estimated numbers of species in several faunal groups living on the shelf and in the basins. Many of the species found in the basins are "shelf" species, and further studies will be required to identify those that are actually indigenous to the basins. In terms of frequency of occurrence (Table II-33), basin polychaetes were eight times more common than crustaceans; on the shelf, polychaetes and crustaceans occurred with about equal frequency. The biomass of similar organisms on the shelf was more than two orders of magnitude greater than in the basins.

(10) Offshore Islands

The eight Southern California offshore (channel) islands have been considered as consisting of two groups: Northern Islands; San Miguel, Santa Rosa, Santa Cruz and Anacapa; and Southern islands; Santa Barbara, San Nicolas, Santa Catalina and San Clemente. These islands contain the only remaining "relatively pristine" marine assemblages in the Southern California region. Also, the northern group of islands has long been considered to lie in an area of transition between southern (Panamic) and northern (North Temperate) faunas (Hewatt, 1946).

Table II-30
PHYSICAL AND BIOLOGICAL DATA FROM THE BASINS OFF SOUTHERN CALIFORNIA*

Basin	Depths		Bottom Temp (°C)	Bottom Dissolved Oxygen (mg/L)	No. of Benthic Samples	No. of Living Species	Mean Standing Crop (g/sq m)	Density (no./sq m)
	Sill (m)	Bottom (m)						
Santa Barbara	475	627	6.3	0-0.3**	5	24	2.8 (42.0)†	50
Santa Monica	737	938	5.0	0-0.3**	19	24	4.4	11
San Pedro	737	912	5.1	0.2	70	115	5.5	31
Santa Cruz	1,085	1,966	4.2	0.8	9	55	3.2	61
San Nicolas	1,106	1,833	3.7	0.5	11	90	5.5	121
Santa Catalina	974	1,357	4.0	0.4	11	119	8.3	123
San Clemente	1,815	2,107	2.6	1.3	6	53	1.5	34
East Cortes	1,415	1,979	3.1	0.9	3	36	6.1	66
Tanner	1,165	1,551	3.8	0.6	6	71	10.0	89
West Cortes	1,362	1,769	3.4	0.8	4	42	4.2	66
Velero	1,902	2,571	2.5	2.0	2	20	4.2	43
Long	1,697	1,938	2.7	1.4	3	54	12.0 (49.7)††	98

*After Hartman and Barnard 1960. Bottom dissolved oxygen and temperature from Emery 1960.

**Water in the extreme bottoms is anoxic.

†With heavy molluscs.

††With one large echiuroid.

Table II-31
COMMON AND CHARACTERISTIC BASIN SPECIES*

<u>Santa Barbara</u>	<u>Santa Cruz</u>	<i>Ceratocephala loveni</i> <i>pacifica</i> (P) <i>Leiochrides hemipodus</i> (P)
<i>Paraonis multibranchiata</i> (P)**	<i>Aricidea uschakovi</i> (P) <i>Paraonis gracilis</i> (P)	
<u>San Pedro</u>	<u>San Clemente</u>	<u>Tanner</u>
<i>Phyllochaetopterus limicolus</i> (P) <i>Protis pacifica</i> (P) <i>Cyclopecten zephyrus</i> (M) <i>Amphiteis scaphobranchia</i> (P) <i>Aricidea nr. suecica</i> (P)	<i>Aricidea uschakovi</i> (P) <i>Ceratocephala loveni</i> <i>pacifica</i> (P) <i>Distichoptilum</i> <i>verrillii</i> (O)	<i>Solemya</i> sp. (M) <i>Aricidea uschakovi</i> (P)
<u>Santa Monica</u>	<u>San Nicolas</u>	<u>West Cortes</u>
<i>Phyllochaetopterus limicolus</i> (P) <i>Protis pacifica</i> (P) <i>Cyclopecten zephyrus</i> (M)	Sipunculids (O) <i>Solemya</i> spp. (M) <i>Ampharete</i> sp. (P) <i>Aricidea</i> <i>uschakovi</i> (P) <i>Tharyx tessellata</i> (P)	<i>Ceratocephala loveni</i> <i>pacifica</i> (P) <i>Aricidea uschakovi</i> (P)
<u>Santa Catalina</u>		<u>Velero</u>
<i>Praxillella</i> spp. (P) <i>Ophiura leptoctenia</i> (E) <i>Asychis lacera</i> (P) <i>Aricidea uschakovi</i> (P) <i>Tharyx tessellata</i> (P)		Not evident, too few samples
	<u>East Cortes</u>	<u>Long</u>
	<i>Aricidea uschakovi</i> (P)	<i>Aricidea uschakovi</i> (P) <i>Onuphis vexillaria</i> (P) <i>Tharyx tessellata</i> (P)

*After Hartman and Barnard 1960.

**Symbols: P = polychaete, M = mollusc, C = crustacean, E = echinoderms, O = other phyla.

Table II-32
NUMBERS OF SPECIES IN SEVERAL FAUNAL GROUPS
FROM THE BASINS* AND COASTAL SHELF**

Group	Basins		Shelf	
	Number†	% of Total	Number††	% of Total
Polychaetes	172	53	523 (336)	35
Crustaceans	32	10	419 (272)	28
Molluscs	(50)	16	408 (268)	29
Echinoderms	17	5	64 (50)	4
Others	(50)	16	59 (11)	4
Estimated Total	321		1,473	

*After Hartman and Barnard (1960), 149 samples.

**After Jones (1969), 176 samples.

†Parenthetic numbers are estimates.

††Parenthetic numbers are actual numbers of species identified; others are total faunal elements, including those forms identified only to family or genus. Overall, only 64% were described and placed to species.

Table II-33
RELATIVE NUMERICAL FREQUENCY OF OCCURRENCE OF SEVERAL FAUNAL
GROUPS CALCULATED FROM INDIVIDUAL FREQUENCIES IN BASIN AND
COASTAL SHELF SAMPLES*

Group	Percent Composition	
	Basin	Shelf
Polychaetes	62	36
Crustaceans	8	35
Molluscs	10	12
Echinoderms	5	14
Sipunculids	(1.6)**	0.3
Others	5	3

*After Hartman and Barnard (1960)

**Unique sipunculid fauna of San Nicholas Basin excluded.

With the exception of San Nicolas Island, the coastlines of the islands are nearly all rocky shores (Graphic 10, Corps of Engineers and Dames & Moore, 1971).

Presumably because of limited accessibility, the benthic invertebrates of the offshore islands have not been adequately described. Ecological accounts are limited to studies of San Nicolas (Caplan and Boolootian, 1967), and Santa Cruz (Hewatt, 1946). Additionally, Given and Lees (1967) prepared a preliminary report on the marine biota of Santa Catalina, and Cockerell (1939) commented on the mollusca from San Miguel, San Nicolas, and San Clemente.

Caplan and Boolootian (1967) studied two rocky areas on San Nicolas. They concluded that the zonation patterns (rocky intertidal area) on San Nicolas was similar to those found on the mainland, (i.e., the intertidal organisms are representative of both northern and southern faunas). However, the study omitted a major portion of the intertidal region (+2.0 ft.).

Hewatt (1946) established species lists for six areas on Santa Cruz: Scorpion Harbor, Smuggler's Cove, Pelican Bay, Prisoner's Harbor, Christy Harbor and Wellis Harbor. A total of 529 marine species was considered including 41 species of fish. The information included in the study was not uniform and in many instances incomplete.

iv. Environmental Impact on Benthic Invertebrates, Southern California Borderland

(1) Overview

The Southern California coastal region contains some of the most rapidly expanding urban complexes in the United

States. The waters within a few kilometers of shore are directly influenced by this intense development. There are both negative and positive aspects of man's influence on these near-shore waters. If the ocean is to continue to satisfy the often conflicting demands of the human population, both aspects of the environmental quality issue must be considered. The degree to which marine ecosystems can be stretched thus become pivotal. Yet, to separate those events which are indigenous to the "Natural" ecosystem from those due solely to man's influences is problematic.

Biological communities evolve with selected capabilities (genetic) for coping with conditions, fluctuations, in the environment. If the environment changes the community changes. Sensitive or inadaptive species may be eliminated, but, by in large, the majority of forms can tolerate some change. There are a number of studies which illustrate this. Records of catch data and observations made over the last 150 years reveal that changes in faunal assemblages have often been associated with non-man induced events: spawning behavior, temperature fluctuations, variable current patterns, etc. (Hubbs, 1948; Radovich, 1961; Straughan, 1970).

(2) Municipal Waste-water Discharges

Municipal waste-water discharges serve as principle sources of environmental stress on benthic invertebrates. Many studies have reported a general distribution of benthic invertebrates with regards to distance from the source of pollution and life zones in polluted areas. Near the outfall, with its high level of wastes, organic matter, bacterial population, and low oxygen content,

there is a zone of little or no life. As the stream of pollution flows away from the outlet, it becomes diluted with natural water, oxygen content increases through tidal mixing, and toxic substances become absorbed by silt and removed from solution. The concentration of organic matter and included bacteria remains high and serves to form a zone of fertilization or enrichment for those animals who can tolerate the semitoxic environment. Usually relatively few species are able to live here, but they reach large numbers due to lesser competition and predation and the enriched food supply. Where water is unaffected by wastes there is an increase in the number of species, but each species is represented by fewer individuals (Filice, 1954).

The ratio of number of species to number of individuals can be measured by various species diversity indices, that of Shannon and Weaver (1963) being the most widely used. One theory concerning the relationship between species diversity and community stability was discussed by Copeland and Fruh (1970). In general, a more stable community has a greater diversity. The structure of a community can be described as a complex of energy-flow pathways. Energy enters by way of the lower trophic levels of the ecosystem and travels through multiple pathways to the top carnivores, forming a web of pathways interconnecting all species in all possible combinations. With many species present in the system, there are more alternate pathways and thus greater stability.

If a system is subjected to an energy-requiring stress, the energy required to survive that added cost will be removed from the energy pool utilized for diversification and specific job responsibilities. The many species doing

specialized jobs will be replaced by fewer species capable of doing generalized jobs. When the energy cost of supporting diverse populations is diverted to survival the resulting community is less diverse and its members more adaptable and capable of survival.

The energy-requiring stress to the system can be many things, including pollution. The additional energy required to survive in a polluted area leaves less of a reserve for meeting additional requirements of naturally occurring stresses such as unusual temperature and salinity fluctuations.

The details of these generalizations vary according to type of pollutant and areal location of the outlet. Most pollution studies have been conducted in fresh water or semi-enclosed bay areas. SCCWRP (1973) conducted benthic studies at four oceanic waste-water discharge areas on the Southern California mainland shelf. The amount and type of pollutants are summarized in Section II.H.2. A synopsis of that discussion follows.

Orange County:

At the Orange County (as well as the Point Loma) outfall special attention was focused on the occurrence of brittle stars and the small clam *Parvilucina tenuisculpta*. Jones (1969) found that two brittle stars, *Amphiodia urtica* and *Amphipholis squamata*, were among the most abundant and frequently occurring species. Barnard and Ziesenhenné (1961) found that these species were reduced or missing in areas with substratum complexity, such as Palos Verdes shelf, San Pedro shelf and San Diego shelf. Because of their wide distribution, dominant ecological position and known sensitivity to stress, the above three species are considered as indicators.

Figure II-50 shows the location of benthic sampling stations near the old and the new Orange County outfalls. Table II-34 shows the abundance of *Amphiodia urtica* and *Parvilucina tenuisculpta* near the old and the new Orange County outfalls both prior to and following the initiation of discharge through the new outfall. There was a marked increase in the ratio of brittle stars to *P. tenuisculpta* after termination of discharge. *P. tenuisculpta* was more abundant during discharge, and brittle stars were more abundant after termination of discharge. At the new outfall, a year after initiation of discharge, the ratio was not very different from predischARGE values, with brittle stars outnumbering *P. tenuisculpta*, the number of both organisms having increased.

Table II-35 summarizes preliminary observations of benthic community characteristics at Station S1, nearest the old outfall. The total benthic invertebrate density decreased from 16,000 to 10,000 organisms/sq m following termination of the discharge. In this same period, the total number of species per sample increased from 65 to 84. Density of crustaceans increased from 1,100 to 1,700 organisms/sq m, and crustacean species increased from 14 to 21 per sample. Polychaete species increased from 32 to 40 per sample; the number of capitellids decreased from 22 to 13 percent of the total polychaete fauna.

Table II-35 also shows the results of Shannon and Weaver's species diversity index (H'). In theory the higher H' the less stressed the community is to the effects from pollution. H' is an index of evenness which attempts to measure only the dominance or evenness of distribution in a sample. Both the species diversity and index of evenness increased after termination of discharge.

Table II-36 shows the 16 species that were most abundant before and after discharge termination. During the discharge period, the 16 species most abundant accounted for 82 percent of the total invertebrate population. However, after termination of the discharge, the most abundant species accounted for only 66 percent of the total population.

Table II-37 presents a summary of the characteristics of benthic macrofauna nearest the new outfall (Station D1). The total population density more than doubled, and the number of species per sample increased from 90 to 100. The number of polychaete species per sample, however, remained nearly constant, and total community diversity decreased.

Table II-38 lists the species most abundant at Station D1 before and after initiation of the discharge, ranked in order of relative abundance. Before the discharge, the most abundant species represented 70 percent of the total number of individuals. This proportion increased to 74 percent in the period after discharge. Most species changed in relative abundance.

Point Loma

Figure II-51 shows the location of benthic sampling stations near the Point Loma outfall. Table II-39 presents the average number of brittle stars (*Amphiodia* spp.) per sample collected at "A" and "B" stations from 1963 to 1972. The general pattern is one of early stimulation of brittle stars, followed by a decline in populations and a shifting of peak abundances to areas farther from the outfall. Table II-40 shows the ratio of brittle stars to clams. The picture that

emerges is one of a declining abundance of brittle stars and an increasing abundance of *P. tenuisculpta*.

The data in Tables II-39 and II-40 show that there was a gradient effect, both with time and initiation of the discharge and also with distance from the outfall. The effect was asymmetric, with stations to the north showing a greater effect, and effect consistent with subsurface current flow.

Palos Verdes

Figures II-52 and II-53 show the location of 87 stations used in a 1971 benthic survey off Palos Verdes. Treatment of the data obtained during the survey are shown in Tables II-41 and II-42.

Data from the survey indicated that the area differed from the usual shelf faunal composition (See Table II-32): Polychaetes contributed 70 percent of the total benthic specimens, and molluscs 27 percent. Crustaceans and echinoderms were low in abundance, and brittle stars were completely absent from samples. *P. tenuisculpta* was abundant over much of the area but was diminished around Whites Point outfall and completely absent from samples taken from a line of stations extending northwest from the "Y" diffuser. The 21 major polychaete species distributions showed typical outfall-related patterns (Table II-42). *Stauronereis rudolphi* and *Capitella capitata* were dominant near the outfall, where highly organic substrate and hydrogen sulfide were noted and sediment levels of metals and DDT were relatively high. Many other species distributed over much of the Palos Verdes shelf were conspicuously absent. The recurrent group analysis has been discussed above under mainland shelf. Species diversity measurements for the

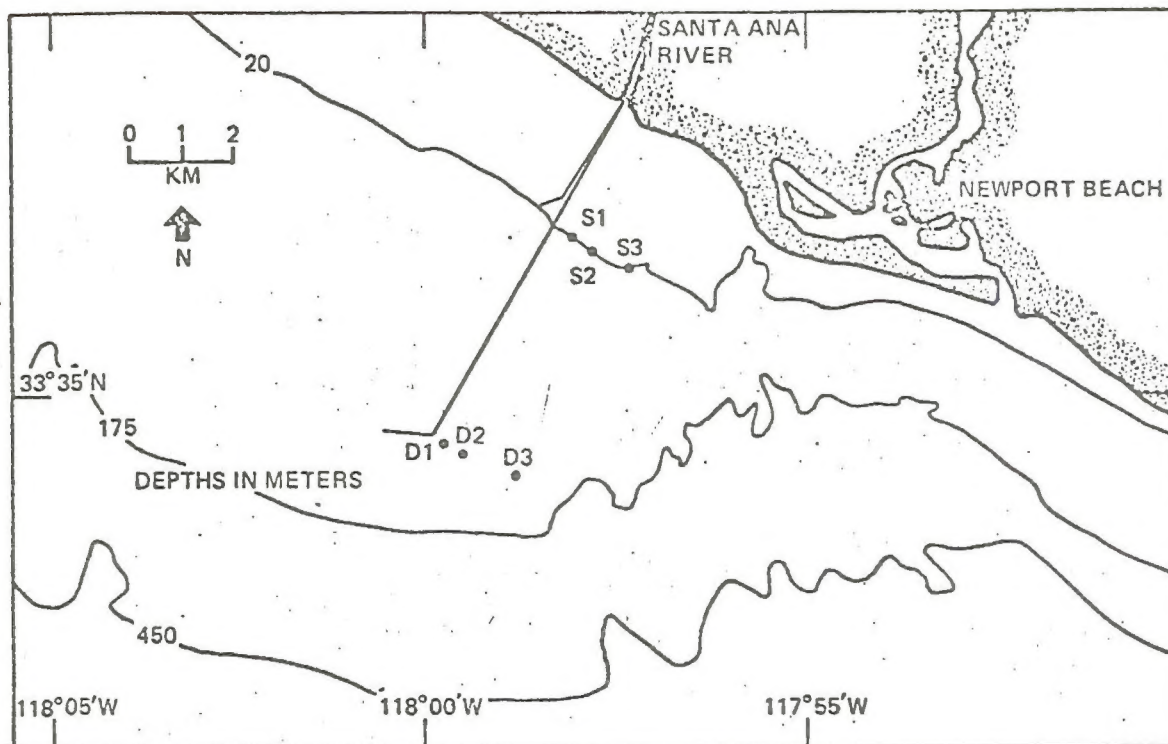


Figure II-50 Location Of Benthic Sampling Stations Near Old and New Orange County Outfalls (SCCWRP, 1973)

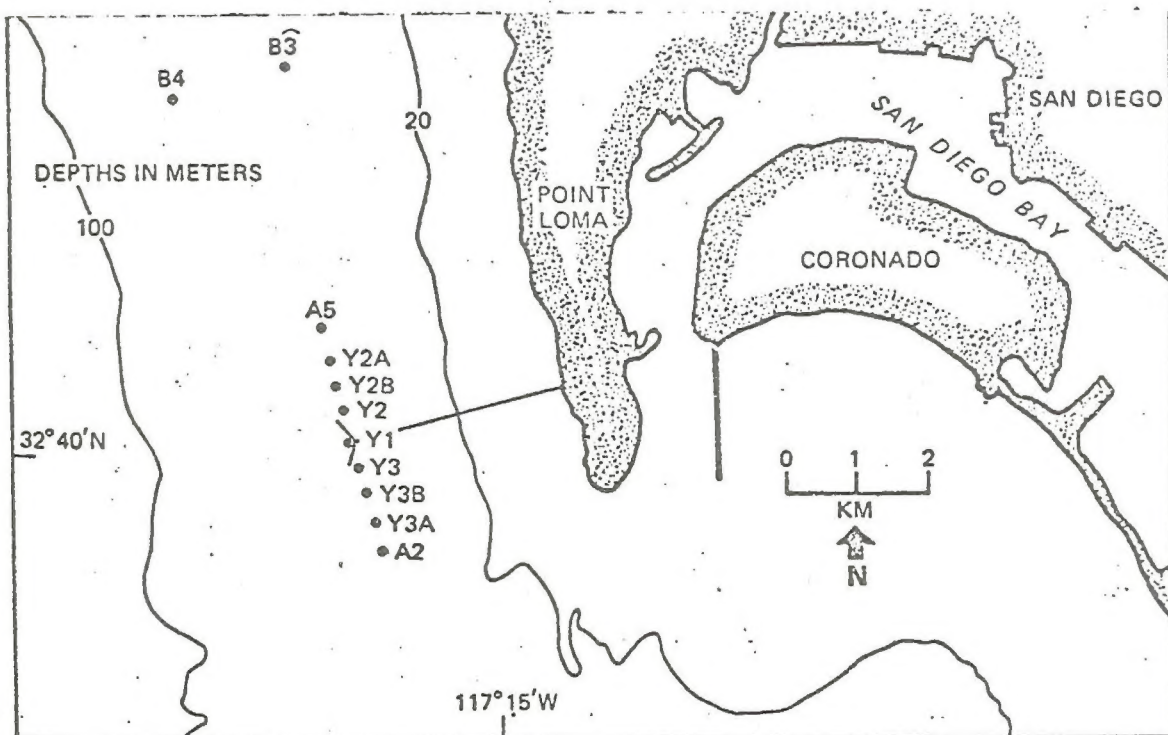


Figure II-51 Location of Benthic Sampling Stations Near Point Loma Outfall (SCCWRP, 1973)

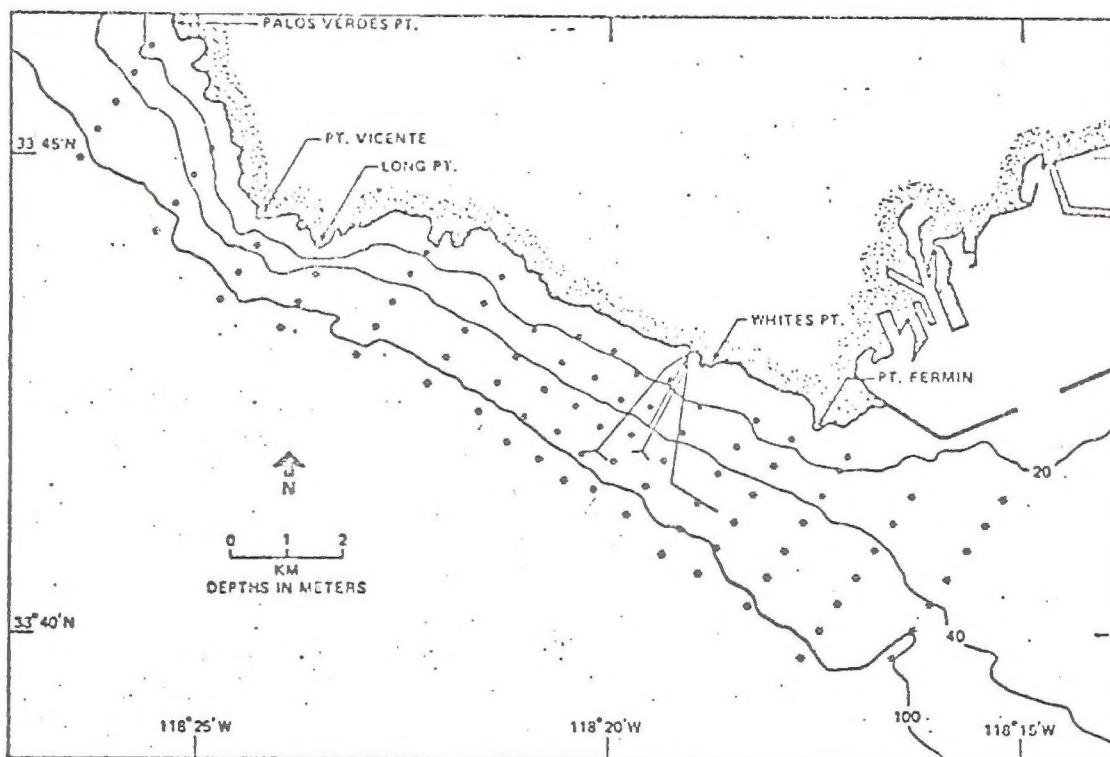


Figure II-52 Eighty-Seven-Station Sampling Grid Used In Benthic Survey Off Palos Verdes, July, 1971 (SCCWRP, 1973)

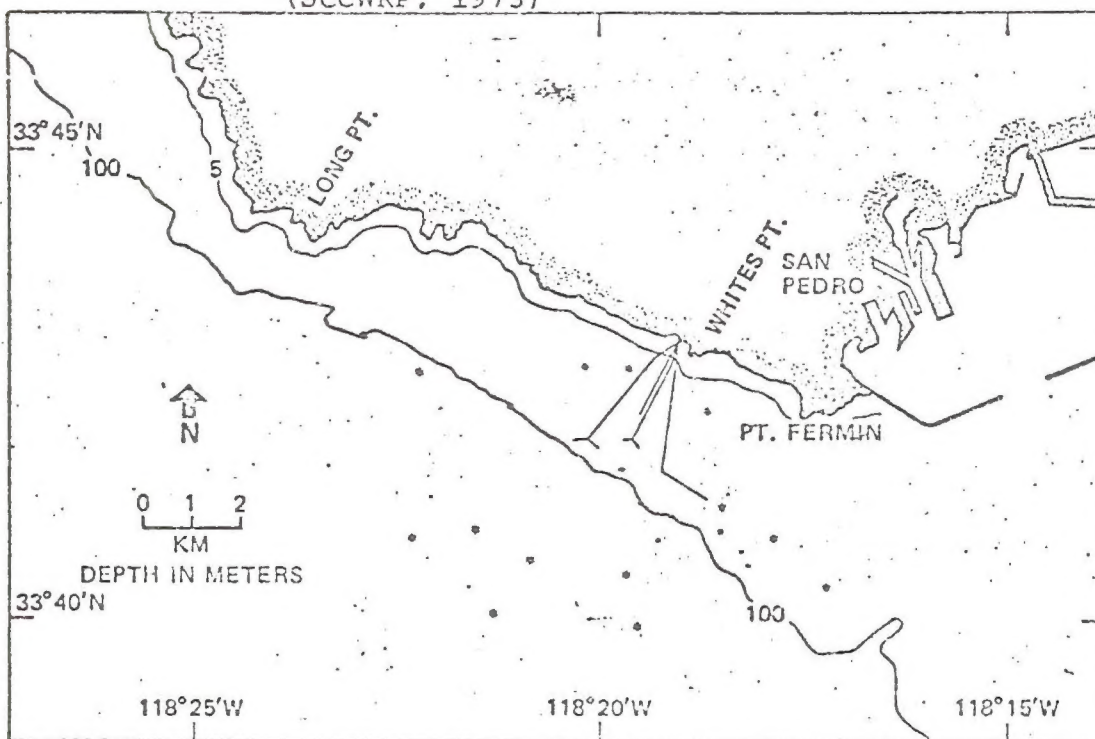


Figure II-53 Fifteen-Station-Sampling Grid Used in Benthic Survey Off Palos Verdes, March, 1971 (SCCWRP, 1973).

Table II-34

NUMBERS AND RELATIVE ABUNDANCE OF Amphiodia urtica
AND Parvilucina tenuisculpta NEAR THE ORANGE COUNTY OUTFALL++

Station	Prior to Outfall Changeover						Mean
	4 Aug 70	1 Sep 70	27 Oct 70	1 Dec 70	5 Jan 71	9 Feb 71	
<u>Old Outfall, Sta. S1</u>							
No. <u>Amphiodia</u> /grab*	27	5	1	1	11	23	11.3
No. <u>Parvilucina</u> /grab	81	117	2	52	45	39	57.7
Ratio, <u>Amphiodia</u> to <u>Parvilucina</u>	0.33	0.04	0.08	0.02	0.24	0.59	0.20
<u>New Outfall, Sta. D1</u>							
No. <u>Amphiodia</u> /grab	84	28	69	32	66	51	55.0
No. <u>Parvilucina</u> /grab	59	34	45	35	58	19	41.7
Ratio, <u>Amphiodia</u> to <u>Parvilucina</u>	1.42	0.82	1.53	0.91	1.14	2.68	1.32
<u>Control, Sta. S4</u>							
No. <u>Amphiodia</u> /grab			10	26			18.0
No. <u>Parvilucina</u> /grab			7	27			17.0
Ratio, <u>Amphiodia</u> to <u>Parvilucina</u>			1.43	0.98			1.06

Table II-34
(Continued)

Station	After Outfall Changeover**					Mean
	22 Jun 71	17 Aug 71	20 Oct 71	Dec 71	Jun 72	
<u>Old Outfall, Sta. S1</u>						
No. <u>Amphiodia</u> /grab*	2	2	113	212	55	76.8
No. <u>Parvilucina</u> /grab	0	10	6	16	9	8.2
Ratio, <u>Amphiodia</u> to <u>Parvilucina</u>	-	0.20	18.83	13.25	6.11	9.37
<u>New Outfall, Sta. D1</u>						
No. <u>Amphiodia</u> /grab	111	155	108	98	126	120
No. <u>Parvilucina</u> /grab	9	59	90	82	61	60.2
Ratio, <u>Amphiodia</u> to <u>Parvilucina</u>	12.33	2.63	1.20	1.20	2.07	2.00
<u>Control, Sta. S4</u>						
No. <u>Amphiodia</u> /grab	1				11.8+	9.6
No. <u>Parvilucina</u> /grab	13				4.5+	6.2
Ratio, <u>Amphiodia</u> to <u>Parvilucina</u>	0.08				2.62	1.5

*Grab area: 0.11 sq m.

**Outfall Changeover occurred 1 April 1971.

+Mean of four samples.

++From SCCWRP, 1973

Table II-35

BENTHIC COMMUNITY CHARACTERISTICS NEAR THE OLD ORANGE COUNTY
OUTFALL (STATION S1) BEFORE AND AFTER TERMINATION OF DISCHARGE
(APRIL 1971)*

Characteristic	Mean (95% Confidence Limits)	
	Before	After
Total individuals/sq m	15,590 (7,160-24,020)	9860 (8,200-11,520)
Total species/sample	65.2 (52.9-77.5)	82.4 (77.2-87.6)
Crustaceans		
Individuals/sq m	1095 (85-2,105)	1695 (590-2,800)
Species/sample	14.0 (9.2-18.8)	21.3 (19.9-22.7)
Polychaetes		
Species/sample	32.2 (26.0-38.8)	39.6 (35.9-42.3)
Species Diversity+		
H'	2.716 (2,486-2.946)	3.256 (2.927-3.585)
H'_s	0.622 (0.564-0.680)	0.723 (0.687-0.759)

*From SCCWRP, 1973

+Based on the Shannon-Weaver (1963) diversity index.

Table II-36
RELATIVE SPECIES ABUNDANCE AT OLD ORANGE COUNTY OUTFALL
(STATION S1) BEFORE AND AFTER TERMINATION OF DISCHARGE
(APRIL 1971)+

Before			AFTER		
Rank	Species	P*	Rank	Species	P*
1	Armandia bioculata (P)*	0.176	1	Capitita ambiseta (P)	0.127
2	Capitita ambiseta (P)	0.114	2	Prionospio pygmaeus (p)	0.100
3	Capitella capitata (P)	0.111	3	Tharyx tessellata (P)	0.057
4	Juvenile polychaetes	0.071	4	Amphiodia urtica (O)	0.056
5	Sipunculids	0.067	5	Chaetozone corona (P)	0.048
6	Stauronereis rudolphi (P)	0.043	6	Juvenile polychaetes	0.047
7	Parvilucina sp. (M)	0.034	7	Nereis procera (P)	0.046
8	Ctenodrilus serratus (P)	0.031	8	Tellina sp. (M)	0.030
9	Eulalia aviculiseta (P)	0.029	9	Asterope sp. (C)	0.026
10	Prionospio pygmaeus (P)	0.027	10	Olivella baetica (M)	0.023
11	Tharyx tessellata (P)	0.027	11	Argissa hamatipes (C)	0.020
12	Photis spp. (C)	0.021	12	Ctenodrilus serratus (P)	0.020
13	Nematodes	0.021	13	Photis spp. (C)	0.018
14	Asterope sp. (C)	0.018	14	Edotea sublittoralis (C)	0.015
15	Tellina sp. (M)	0.016	15	Munna ubiquita (C)	0.014
16	Anaitides longipes (P)	0.013	16	Ampelisca spp. (C)	0.013
		0.819			0.660

+ From SCCWRP, 1973

* Proportion of mean total individuals/sq. m.

**Symbols: P=polychaete, M=mollusc, C=crustacean, O=ophiuroid.

Table II-35

BENTHIC COMMUNITY CHARACTERISTICS NEAR THE NEW ORANGE COUNTY
OUTFALL (STATION D-1) BEFORE AND AFTER INITIATION OF DISCHARGE
(APRIL 1971)*

Characteristic	Mean (95% Confidence Limits)	
	Before	After
Total individuals/sq m	7,010 (5,580-8,440)	14,700 (9,510-19,890)
Total species/sample	89.9 (80.5-99.3)	100.6 (96.0-105.2)
Crustaceans		
Individuals/sq m	1,005 (665-1345)	2,325 (1610-3040)
Species/sample	25.3 (21.8-32.3)	31.0 (28.7-33.3)
Polychaetes		
Species/sample	40.3 (35.7-44.9)	41.6 (38.8-44.4)
Diversity		
H'	3.508 (3.368-3.648)	3.257 (3.023-3.591)
H'_s	0.729 (0.701-0.757)	0.669 (0.626-0.712)

*From SCCWRP, 1973

Table II-33
RELATIVE SPECIES ABUNDANCE AT NEW ORANGE COUNTY OUTFALL
(STATION D-1) BEFORE AND AFTER INITIATION OF DISCHARGE
(APRIL 1971)+

Before			After		
Rank	Species	P*	Rank	Species	p*
1	Lumbrinereis spp. OP)**	0.110	1	Capitita ambiseta (P)	0.257
2	Prionospio pygmaeus (P)	0.105	2	Amphiodia urtica (O)	0.069
3	Axinopsida serricata (M)	0.068	3	Axinopsida serricata (M)	0.053
4	Amphiodia urtica (O)	0.067	4	Lumbrinereis spp. (P)	0.051
5	Tharyx tessellata (P)	0.055	5	Leptostylis sp. (C)	0.045
6	Parvilucina sp. (M)	0.054	6	Parvilucina sp. (M)	0.042
7	Capitita ambiseta (P)	0.043	7	Tharyx tessellata (P)	0.034
8	Glycera capitata (P)	0.030	8	Juvenile polychaetes	0.032
9	Leptostylis sp. (C)	0.030	9	Prionospio pygmaeus (P)	0.029
10	Aricidea neosuecia (P)	0.023	10	Nematodes	0.024
11	Spiophanes missionensis (P)	0.020	11	Pectinaria californiensis (P)	0.021
12	Juvenile polychaetes	0.020	12	Photis spp. (C)	0.021
13	Nematodes	0.020	13	Glycera capitata (P)	0.019
14	Ctenodrillus serratus (P)	0.018	14	Aricidea neosuecia (P)	0.018
15	Ostracod sp. (C)	0.016	15	Exogone uniformis ()	0.014
16	Sthenelanelia uniformis (P)	0.016	16	Ampelisca spp. (C)	0.012
		69.900			74.100

+ From SCCWRP, 1973

* Proportion of mean total individuals/sq m.

** Symbols: P = polychaete, M = mollusc, C = crustacean, O = ophiuroid.

Table II-39
MEAN NUMBER OF BRITTLE STARS (*Amphiodia* spp.)
PER GRAB OFF POINT LOMA+

Station and Distance from Outfall						
Period	No. of Sampling Periods*	B-1, 1.0 km S	A-2, 2 km S	A-5, 2 km N	B-3, 1.0 km N	B-4, 1.0 km N
1963	9	1.2	46.8	61.0	44.0	33.3
1964	9	1.3	44.7	69.3	42.0	39.6
1965	9	1.8	52.7	73.0	84.0	54.0
1966	6	1.8	86.8	54.8	97.6	95.8
1968-72	6	1.6	25.3	11.7	63.6	85.3

+ From SCCWRP, 1973

* Normally, four grab samples were taken in each sampling period.

Table II-40
RATIO OF BRITTLE STARS (*Amphiodia* spp.) TO CLAMS (*Parvilucina tenuisculpta*) OFF
POINT LOMA+

Station and Distance (km) from Outfall												
Date	B-1, 10 S	A-2, 3 S	Y-3A, 2.4 S	Y-3B, 1.6 S	Y-3, 0.8 S	Y-1, 0	Y-2, 0.8 N	Y-2B, 1.6 N	Y-2A, 2.4 N	A-5, 3 N	B-3, 10 N	B-4, 10 N
1963												
Sep	1*	52*								72*	34	38*
Oct	0.29	74								34	42	20
Nov	0.17	98*								30	38	40
Dec	0.12	18								30	45	31*
1964												
Jan	0.25	71								36	22	20*
Feb	0.12	38*								14	36	32*
Mar	0.09	20								17	44	28*
Apr	0.20	31								16	38	40*
May	0.60	36								24	66*	37*
Jun	0.67	27								37	48*	42*
Jul	0.14	42								15	34	51
Sep	0.10	20								12	14	41
Nov	0.10	50*								3.8	49	65*
1965												
Jan	0.12	20			6.9	0.34	1.1			22	80	47*
Mar	0.14	7.3	5.4		2.5	0.05	0.01		7.8	9.2	32	40*
May	0.44	22	31	6.5	2.1	0.02	0.007	1.1	70	7.8	29	53*
Jul	0.11	11								26	66	53
Sep	0.20	11	9	3.0	0.24	0.004**	0.10	0.26	1.0	4.6	96	62*
Nov	0.17	14	8.2	17	10	0.003**	0.10	0.21	1.6	7.2	108	69*
1966												
Jan	0.07	14	6.5	1.4	0.008*	0.003	0.003**	0.10	1.3	2.6	121	71*
Mar	0.11	6.6								5.3	106	92*
May	0.14	6.2	4.7	1.3	0.01		0.02	0.26	1.2	3.7	122	82*
Jul		130*								54*		
Sep	1.0									3.1	89	102*
Nov	0.29	1.7								2.8	50	132*

Table II-40 (continued)

Station and Distance (km) from Outfall												
Date	B-1, 10 S	A-2, 3 S	Y-3A, 2.4 S	Y-3B, 1.6 S	Y-3, 0.8 S	Y-1, 0	Y-2, 0.8 N	Y-2B, 1.6 N	Y-2A, 2.4 N	A-5, 3 N	B-3, 10 N	B-4, 10 N
1968												
Feb		0.59										
Jul	0.07	0.20									112*	19*
1969										0.27	3.6	56
Jan	0.25	0.29										
1970										0.34	8.8	94
Nov	6.0	0.67										
1971										0.17	6.5	33
Jul	0.4	1*										
1972										0.47	0.38	13*
Jan	0.23	4.7										
Jul	1**	1.5		0.32		0.008**		0.045**		0.85 5*	2.1 4.2	242 140*

+From SCCWRP, 1973

*No clams in sample; number given is the number of brittle stars.

**No brittle stars in sample; number given is 1/(no. of clams).

Table II-41
DISTRIBUTIONAL CHARACTERISTICS OF THE 21 MOST FREQUENTLY OCCURRING POLYCHAETE
SPECIES OFF PALOS VERDES, JULY 1971+

	Abundance Ranking	% of Total Polu- chaete Specimens	Frequency of Occurrence		Mean Density (specimens/sq m)		Apparent Sediment Preference
			All Stations	High Organic Substrate Stations*	All Stations	High Organic Substrate Stations*	
<i>Staurochoreis rudolphi</i>	1	37.6	80	100	1678	3136	Silt
<i>Nereis procera</i>	8	1.2	55	58	53	58	Silt
<i>Tharyx parvus</i>	2	25.5	54	5	1139	12	Sandy silt
<i>Capitita ambiseta</i>	4	7.6	53	16	331	7	Sandy silt
<i>Caulleriella hamata</i>	3	12.0	53	7	549	95	Silt
<i>Ophiodromus pugettensis</i>	7	1.2	53	58	51	53	Silt, s. silt
<i>Capitella capitata</i>	5	4.7	49	68	208	409	Silt, s. silt
<i>Telepsavus costarum</i>	6	1.5	46	37	68	60	Silt, s. silt
							silty sand
<i>Notomastus tenuis</i>	10	0.9	36	16	39	7	Sandy silt
<i>Spiophanes fimbriata</i>	9	0.9	36	5	40	7	Sandy silt
<i>Prionospio malugreni</i>	14	0.4	29	0	17	0	Sandy silt
<i>Ampharete labrops</i>	12	0.5	26	0	24	0	Sandy silt
<i>Lumbrineris japonica</i>	13	0.5	24	0	20	0	Sandy silt,
							silty sand
<i>Pectinaria calif.</i>	11	0.6	20	0	29	0	Silty sand
<i>Glycera capitata</i>	18	0.1	16	0	6	0	Sandy silt
<i>Chloecia entypa</i>	16	0.3	15	5	12	4	Sandy silt
<i>Prionospio pinnata</i>	21	0.1	15	21	4	5	None
<i>Cossura condida</i>	15	0.3	10	0	14	0	Sandy silt
<i>Gyptis arenicola glabra</i>	17	0.2	10	16	7	8	None
<i>Lumbrineris minima</i>	19	0.1	10	0	6	0	None
<i>Pherusa neopapillata</i>	20	0.1	10	5	5	1	Silty sand

* From SCCWRP, 1973

*Stations in area of highly organic substrate shown on Figure 8-5b.

Table II-42
DISTRIBUTIONAL CHARACTERISTICS OF THE 21 POLYCHAETE SPECIES
MOST FREQUENTLY APPEARING IN SAMPLES TAKEN OFF
PALOS VERDES, JULY 1971*

GROUP A--Species preferring the outfall area or areas
of finest sediment:

1. *Stauronereis rudolphi*
2. *Capitella capitata*
3. *Nereis procera*
4. *Glyptis arenicola glabra*

GROUP B--Species not displaying a strong preference for or
against the outfall area or areas of finest
sediments:

1. *Ophiodromus pugettensis*
2. *Prionospio pinnata*

GROUP C--Species avoiding the outfall area or areas of finest
sediments:

1. *Caulleriella hamata*
2. *Telepsavus costarum*
3. *Capitita ambiseta*
4. *Tharyx parvus*
5. *Notomastus tenuis*
6. *Spiophanes fimbriata*
7. *Chloeia entypa*
8. *Ampharete labrops*
9. *Lumbrineris japonica*
10. *Prionospio malmareni*
11. *Glycera capitata*
12. *Pherusa neopaipillata*
13. *Pectinaria californiensis*
14. *Cossura candida*
15. *Lumbrineris minima*

* From SCCWRP, 1973

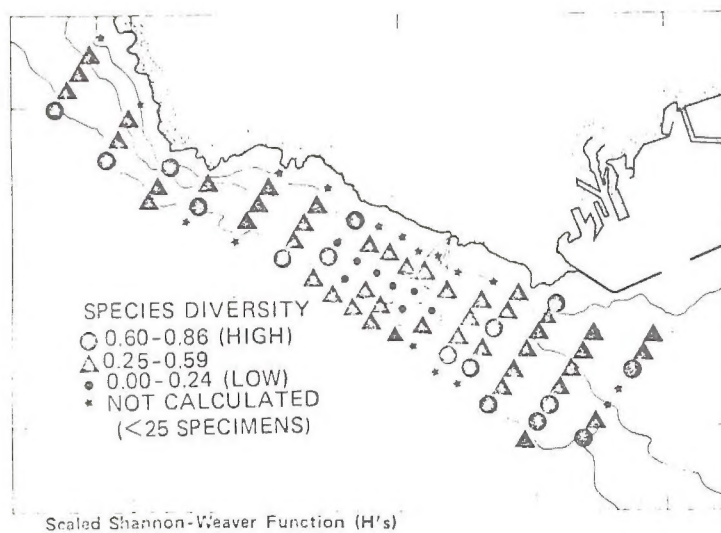
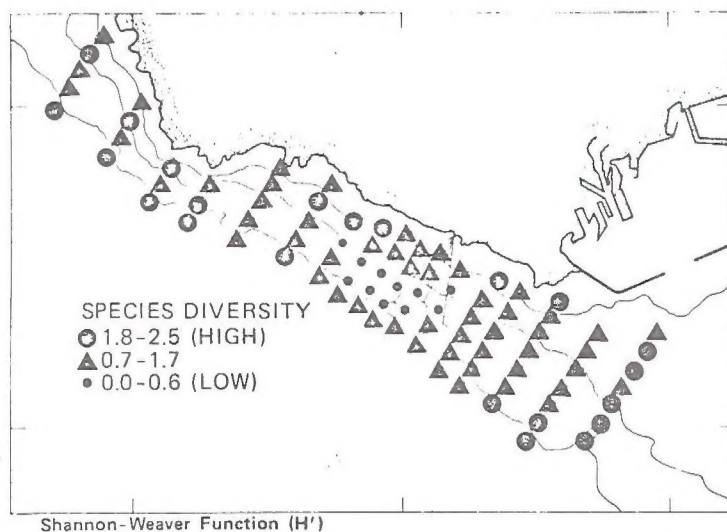


Fig. II-54 Analyses of Polychaete Species Diversity Off Palos Verdes, July 1971.

polychaete community of the Palos Verdes shelf showed distinctly lower values in the area immediately around the outfall as compared to those more distant (Figure II-54). The site-groups presented on Figure II-49 nearest the sewage outfall, had fewer species than areas further away. The results from the Palos Verdes area, therefore, generally agree with the description of a benthic community in polluted semi-enclosed bays (Filice, 1954; and Copeland and Fruh, 1970).

(3) Disease and Abnormalities in Benthic Invertebrates

Individual species vary in ability to withstand stress. Some species show few external signs of stress while others show dramatic changes. Several recent studies have lead to the belief that certain diseases and abnormalities in benthic invertebrates are directly related to changes in water quality brought about by the introduction of municipal waste-water into the nearshore environment.

Although considerable data have been collected on similar conditions for algae (Section II.E.3.a.) and fish (II.E.4.) only minimal data have been collected on benthic invertebrates.

Exoskeletal lesions in crabs: Exoskeletal lesions in crabs appear to be related to "burn-spot disease". Sindermann and Rosenfield (1967) indicated that more than one causitive factor may be involved, and that the lesions are contagious but generally lost as a consequence of molting.

Specimens of *Mursia gaudichaudii* and *Cancer* spp. with lesions have been taken during trawling off Palos Verdes, Santa Monica and Newport Beaches as far seaward as the 405' contour. The occurrence (based on

small samples) of the lesions is variable, from 0 to 70 percent.

Although the data are limited, they indicate that, near the heads of canyons, lesions occur on small crabs, and, in areas away from canyons, the larger crabs are affected; this suggests that the crabs may themselves spread the disease. Further studies are needed on the causative factor together with a more carefully designed sampling program.

Abnormalities and disease in sea urchins:

Unhealthy appearing sea urchins (*Strongylocentrotus purpuratus* and *S. franciscanus*) from Whites Point have been taken exhibiting the following abnormalities: 1) spine loss, 2) gonadal atrophy, and 3) aberrations in the hemal axial gland and water vascular system. Johnson (1971a,b) speculated that these conditions were due to stress from sub-optimal, food-impooverished environmental conditions. Moitza (1971) indicated that it is also possible that these conditions are related to high levels of DDT. Much additional data are needed before conclusive remarks are possible regarding the above abnormalities in sea urchins. Perhaps the kelp reforestation projects will provide some insight into the problem as well.

(4) Chlorinated Hydrocarbons and Metals and Benthic Invertebrates

In recent years there have been many investigations of the effects of chlorinated hydrocarbons and metals on a wide variety of life forms. Table E3-2 (Appendix 10, Section 3) taken from SCCWRP (1973) summarizes the results of a number of the more recent studies made on marine and estuarine invertebrates relative to chlorinated hydrocarbons. Table E3-3 (Appendix 10, Section 3) lists the relative toxicities of ten metals in sea-

water to marine and estuarine organisms.

Concentrations of DDT in intertidal mussels collected during 1971 from along the Southern California Borderland reflect clearly the influence of the Los Angeles County discharge (SCCWRP, 1973; Burnett, 1971). Distinct gradients were observed in all directions away from this outfall system. Highest levels (4 mg/wet kg) were observed in specimens collected on the Palos Verdes Peninsula. These high concentrations were almost certainly the result of a major long-time discharge of DDT through the Whites Point Outfall system.

High concentrations of total PCB were also observed in intertidal mussels collected from Palos Verdes (SCCWRP, 1973). Levels generally decreased away from this location, except that a secondary peak in distribution was observed at Point Loma in San Diego. This pattern suggests that, in contrast to the case for DDT, there are several significant sources of PCB along the coast.

Conclusive evaluation of the significance of elevated levels of metals in sediments around various outfalls to benthic invertebrates is not available (Bryan, 1971; Portmann, 1970). The apparent lack of uptake by fishes feeding on invertebrates suggests that metals in contaminated sediments are for the most part unavailable. For example, tissues of mussels and gooseneck barnacles were analyzed for a number of metals and there was no obvious pattern associated with waste-water discharge.

Obviously, considerable additional studies, both general and specific, are needed before any viable conclusions can be drawn.

4. The Active Swimmers - Nekton

a. Introduction

With only minor changes, this section is taken from M. H. Horne (1974) of the Southern California Ocean Studies Consortium. The marine environment off Southern California with its diverse chemical, physical, and geological characteristics provides a wide variety of habitats for fishes. Three water masses, North Pacific Central Water, Pacific Subarctic Water, and Equatorial Pacific Water, converge in the region and give it the character of a transition zone between southern warm-temperate, sub-tropical waters and northern cold-temperate waters (Lavenberg and Ebeling, 1967). Organisms including fishes of both warm-water and cold-water affinities are found either seasonally or year-round off Southern California. A major current that is part of the clockwise North Pacific gyral system - the cold, southward-flowing California current - sweeps down into the region just offshore, and, in the complex region of interspersed islands and deep basins, breaks up into eddies and reversed flows. Counter (northward-flowing) currents such as the Davidson Current develop periodically during the year, and seasonal upwelling occurs (approximately from March to July) bringing cold water and nutrients into the surface layers and creating localized areas of lower temperature and high productivity along the coast.

Several deep basins of varying depth and chemico-physical characteristics occur landward and seaward of the Channel Islands and provide habitats for a true deep-sea fish fauna not far from the mainland. The offshore islands serve as partial isolating factors for the fish fauna, result in a further subdivision of the environment, and add

substantially to the length of the shoreline and the amount of coastal habitat available (island coast accounts for 51% of the 990 km of Southern California shoreline). Various substrates ranging from mud and sand to coarse gravel and bench rock occur in the region. In this heterogeneous marine environment one can expect to find and does find a diverse fish fauna. Of the 554 species of coastal marine fishes known to occur in California (Miller and Lea, 1972), 481 species (87%) are found in Southern California waters (Point Conception to Mexican Border). The list compiled by Miller and Lea includes only part of the deep-sea fauna so that for the entire Southern California Bight, the number of species exceeds the figure above. For California coastal waters, the number of species decreases in a south to north direction (Table II-43). Of the 144 fish families listed for California by Miller and Lea (1972), 129 (90%) occur in Southern California, and as with species, fish family diversity decreases from south to north (Table II-43). Thus the diversity patterns for both fish families and species reflects the environmental heterogeneity and diversity of life of Southern California waters.

The 10 fish families with the most species occurring in Southern California are listed in Table II-44. The list serves to distinguish and provide reference to important groups, but does not indicate that these 10 are necessarily the most important. Several families with fewer (including single) species are significant and conspicuous elements of the fish fauna (e. g., Rajidae, Clupeidae, Engraulidae, .

Table II- 43

NUMBER OF SPECIES AND FAMILIES OF PRINCIPALLY COASTAL
FISHES IN SOUTHERN, CENTRAL, AND NORTHERN CALIFORNIA¹

Region	Species	Families
Southern California	481	129
(Mexican border to Point Conception)		
Central California	396	118
(Point Conception to San Francisco)		
Northern California	333	102
(San Francisco to Oregon border)		

¹Data from Miller and Lea (1972)

Table II-44

THE 10 FAMILIES OF FISHES WITH THE MOST SPECIES OCCURRING IN
SOUTHERN CALIFORNIA

Family	Common Name	Number of Species
Scorpaenidae	Scorpionfishes and rockfishes	55
Cottidae	Sculpins	34
Embiotocidae	Surfperches	18
Pleuronectidae	Righteye flounders	18
Myctophidae	Lanternfishes	16
Scombridae	Mackerels and tunas	14
Carangidae	Jacks and pompanos	13
Gobiidae	Gobies	13
Clinidae	Clinids	12
Carcharhinidae	Requiem sharks	12

I

Data from Miller and Lea (1972) except Myctophidae from Ebeling, et al. (1970b).

Bathylagidae, Atherinidae, Zoarcidae, Serranidae, Sciaenidae, Agonidae, Anoplopomatidae, Hexagrammidae, Bothidae, and Cynoglossidae).

Four orders of bony fishes are well represented: 1) Clupeiformes (herrings and relatives) which includes the Engraulidae; 2) Salmoniformes (salmon and relatives) which includes the deep-sea families Bathylagidae, Gonostomatidae, and Myctophidae; 3) Perciformes (largest order of spiny-rayed fishes) which includes the Embiotocidae, Scombridae, Carangidae, Clinidae, Gobiidae, Serranidae, Scorpacnidae and Cottidae, Anopjromatidae, Agonidae, and Hexagrammidae; and 4) Pleuronectiformes (flatfishes) which includes the Pleuronectidae, Bothidae, and Cynoglossidae.

In compiling the summary of information on fishes the organization that has been adopted is as follows: The marine environment has been divided into two main regions, 1) the shelf of the mainland and offshore islands, and 2) the deep-sea basins. A third recognized region is the general pelagic zone, including the epipelagic, the upper 150 m of the ocean. Epipelagic fishes occur in the upper layer over both the shelf and deep basins, and some of the species are trophically linked to organisms from both regions. Overlap in species composition is also apparent between the shelf and deep basin faunas particularly in transition areas such as the deep shelf continental slope, and surface layers. Therefore, while distinct and recognizable adaptive zones exist and can be usefully designated, none is mutually exclusive, and one zone grades into the adjacent one. All the fish families known to occur in Southern California waters are listed in Table E.4-1 along with their adaptive zone, number of species occurring in Southern California, and

* See Appendix 10,E.4.

food habits by major category.

For fishes of each major region (shelf and deep basin), information is summarized on distribution and seasonality, diversity and abundance, principal species, species associations, food habits and trophic relationships, and reproduction and early life history. Kelp beds, semi-enclosed bays and estuaries, and man-made structures are discussed as special subdivisions of the shelf zone. Reference is frequently made to demersal and pelagic fishes. Demersal forms are substrate oriented or influenced and generally include the shelf species. Pelagic forms swim above a fixed substrate and generally include the epipelagic species and the midwater fishes of the deep basins. Some shelf or coastal fishes such as anchovies are frequently termed pelagic.

The final section of the chapter is on diseases and environmental stresses. It includes information on concentrations of trace constituents, diseases, asymmetry, effects of wastewaters, kelp harvesting, and fluctuations of kelp beds and of fishing. Fisheries resources are discussed in Section II.F.4. A Discussion of impacts is presented in Section III.C.2.b.

b. Fishes of the Mainland and Island Shelf

i. Distribution and Seasonality

Factors known to affect the distribution of fishes are temperature, light, currents, food availability and the presences or absence of predators (SCCWRP, 1973a). That temperature is a major factor affecting distribution of shelf fishes can be supported by paleontological and historical data, and present-day information. Hubbs (1960) reported that the distribution of the coastal fish fauna of the eastern North Pacific was influenced by glacial and interglac-

ial periods in the Pleistocene epoch. During glacial periods the fauna was displaced southward and during interglacial periods displaced northward. According to Hubbs, tropical elements tend to persist northward in California only in bays whereas northern species extend southward along the open coast where temperatures are lowered by upwelling. These distributional patterns are considered as outcomes of the Pleistocene latitudinal shifts.

Today Point Conception is recognized as a faunal boundary, and roughly the northern limit of the distinctive San Diegan fauna. Based upon examination of a large number of fish otoliths from Pleistocene deposits in Southern California, Fitch (1967) showed that many of the species identified represented a fish fauna to be found today off central and northern California. He inferred that the deposits were laid down during a period when ocean temperatures were colder than they are today at the same latitude.

Data on historical temperature fluctuations also illustrates the extent to which temperature affects fish distributions. Radovich (1961) summarized information showing that after nine consecutive years of subnormal temperatures, ocean temperatures off the Pacific Coast of North America warmed up in 1957 and remained high through 1959. He found that concurrent to this warming trend many southern fishes wandered north of their usual range and some warm-water forms spawned successfully off Southern California. An analysis by Radovich of previous temperature records show similar intrusions of southern species during earlier warm-water years. The decline of the Pacific sardine in the early 1950's may have been at least partly due to subnormal

temperatures in California coastal waters at that time (Marr, 1960; Watt, 1968) although this view has been disputed by Murphy (1966). Whatever the role of temperature in the reduction of the sardine population, the species has been largely replaced by the northern anchovy, a direct food competitor (Frey, 1971) and a fish with apparently a slightly lower temperature optimum (Watt, 1968). At present the anchovy is abundant and the sardine scarce (Ahlstrom, 1965; Frey, 1971).

Sette (1960) has explained how ocean currents, as well as temperatures, regulate the survival of sardines off the west coast of North America. Larvae will have a high probability of survival only if they can migrate to the coastal nursery grounds where conditions for development out of their planktonic phase are optimal. If instead they are swept into nonnursery areas by strong currents, survival will be very low. According to Sette, in years when the California Current is strong and steady, moving southward down the California coast and then outward toward the central Pacific, sardine survival is low and year classes are weak. Conversely in years when the current is weak, the year classes are stronger and the population larger.

SCCWRP (1973a) has shown that some demersal fish populations in Santa Monica Bay respond to changes in bottom water characteristics that occur in early summer by accumulating in relatively high densities in inshore waters. When the seasonal upwelling occurs, many shelf fish generally avoid the intruding offshore waters by moving either inshore (demersal fishes) or to the surface and offshore (pelagic fishes). The factors that affect the demersal fishes are most likely decreasing temperature or decreasing dissolved oxygen. The

dissolved oxygen in the areas farthest from shore, in Santa Monica bay, did not appear to reach limiting levels for fishes (all values > 3.0 mg/l); the bottom temperature changes associated with upwelling were sufficient to cause major changes in the distribution of affected fish populations (SCCWRP, 1973a). A recent trawling survey in Southern California waters (September 1973) by SCCWRP (1973b) showed a completely different pattern of fish species diversity than their 1969 - 1972 survey (SCCWRP, 1973a) of the same areas. In the 1969 - 1972 survey, species diversity was highest in San Pedro Bay followed by Santa Monica Bay then Palos Verdes. In the 1973 survey, diversity was highest off Palos Verdes followed by Santa Monica Bay then San Pedro Bay. Catches of the 1973 survey in deep waters, where temperature and dissolved oxygen were lowest, were as much as 10 times greater than the shallow water catches. As a result of these differing results, SCCWRP is now carefully analyzing the catch data for common fishes in relation to temperature and dissolved oxygen ranges.

ii. Diversity, Abundance, and Principal Species

A list of shelf species compiled from various sources and either captured by trawling or captured or recorded by diving is given in Table 11-4 in Horn (1974). The first seven sources in the table were taken from a checklist compiled by Mearns and Allen (1973). The eighth and ninth columns in the table are lists compiled by Turner, Ebert, and Given (1969) for man-made reefs and by Quast (1968a) for kelp beds, respectively. These two habitats are discussed in subsequent sections b.vi. for kelp beds and b.viii for man-made

reefs). The final column in the table lists the species taken in a recent trawling survey in San Pedro Bay by Stephens, Gardiner, and Terry (1973). A total of 213 species and 66 families is listed in Table 11-4 in Horn, (1974) and represents 44% of the 481 species of fishes (mainly coastal) listed by Miller and Lea (1972) as occurring in Southern California waters (see Table II-43).

SCCWRP (1973a) reported that many of the nearshore demersal fishes found in Southern California are found along the entire coast as far north as British Columbia (generally supported by Table II-43). They further noted that deep water species, such as the slender sole (*Lyopsetta exilis*) and rexsole *Glyptocephalus zachirus*, are essentially cool-water, temperate fishes, with centers of distribution lying to the north of the Southern California Bight and that a distinct San Diegan fauna does not occur below the thermocline or in the deeper waters of the coastal shelf. Stephens, Gardiner, and Terry (1973) reached generally the same conclusions.

The most comprehensive sampling yet carried out in Southern California waters was the 1969-1972 trawling survey reported by SCCWRP (1973a) and conducted by SCCWRP and many other workers and institutions. It showed that based on 303 collections, at least 121 species representing 41 fish families were present on or near the bottom of the coastal shelf at depths of 10 to 360 m (see column one of Table 11-4 in Horn, 1974) SCCWRP estimated that the species collected account for one-quarter to one-third the total fish species in the Southern California Bight (see Table II-43) and approximately one-half the local coastal zone species. Scorpionfishes (rockfishes), sharks and rays, and flatfishes were best represented in the samples in terms of numbers of species collected.

The 20 most commonly encountered species ranked by frequency of occurrence as a total for the 303 SCCWRP trawls and for each of the five general sampling areas are listed in Table E.4-2 (Appendix 10, E.4). Dover sole (*Microstomus pacificus*) was the most frequently encountered species, and flatfishes made up six of the seven most frequently found species. Dover sole was the most frequently occurring species off Palos Verdes and in San Pedro Bay, hornyhead turbot (*Pleuronichthys verticalis*) was most frequent at Port Hueneme, speckled sanddab (*Citharichthys stigmaeus*) and plainfin midshipman (*Porichthy notatus*) in Santa Monica Bay, and Pacific sanddab (*Citharichthys sordidus*) the most frequently encountered off Santa Catalina Island. Generally, each area seemed to be characterized by certain principal species.

The most abundant fish in the SCCWRP sample was the speckled sanddab followed by the Pacific sandab, the dover sole, and the stripetail rockfish (*Sebastes saxicola*) Table E.4-3 Appendix 10, E.4. Together, these four species accounted for almost 50% of all the coastal fishes captured in the 303 SCCWRP trawls. The 20 most abundant species accounted for slightly over 90% of the fishes captured. The differences in frequency and abundance ranking (Tables E.4-2 and E.4-3 Appendix 10, E.4 indicate that certain species are not uniformly distributed over the shelf but occur in distinct concentrations. For example, white croaker (*Genyonemus lineatus*) occur in high density in certain areas while English sole (*Paraphrys vetulus*) are widely but sparsely distributed in the areas sampled.

Each of the 303 10-minute trawls made by SCCWRP yielded an average

of 12 species and a median of 193 fish. Shannon-Weaver diversity indices ranged from 1.3 off Palos Verdes to 1.7 off the Santa Ana River in Orange County (SCCWRP, 1973a). SCCWRP found an apparent marked decrease in diversity with increasing latitude. Diversities per haul at the northern end of the Bight, around Point Hueneme, were significantly smaller than those off Orange County. However, as pointed out by SCCWRP, the data for each area were collected at different seasons with different combinations of vessels and trawling gear. Thus, firm conclusions cannot yet be drawn on interareal diversity. A definite need exists for increased standardization in the design and use of trawls for survey work.

iii. Species Associations

Using recurrent group analysis, SCCWRP (1973a) recognized from their trawl survey data a set of species groups of near-shore demersal fishes. The analysis showed that about one-fifth of the 121 species captured in 1969-1972 surveys appeared in statistically significant associations. The groups are listed in Figure II-55; the first species named in each group list is the dominant member of the group. The distributions of the five recurrent groups are given in Figure II-56 (a-e).

The groups may or may not represent complete fish communities since the data were collected by a single method, trawling (in the daytime only), which has an apparent selectivity for smaller and less mobile species. As SCCWRP points out, for complete and representative data both day and night sampling must be conducted and with additional methods such as longline fishing, purse seining, fish trapping, and in

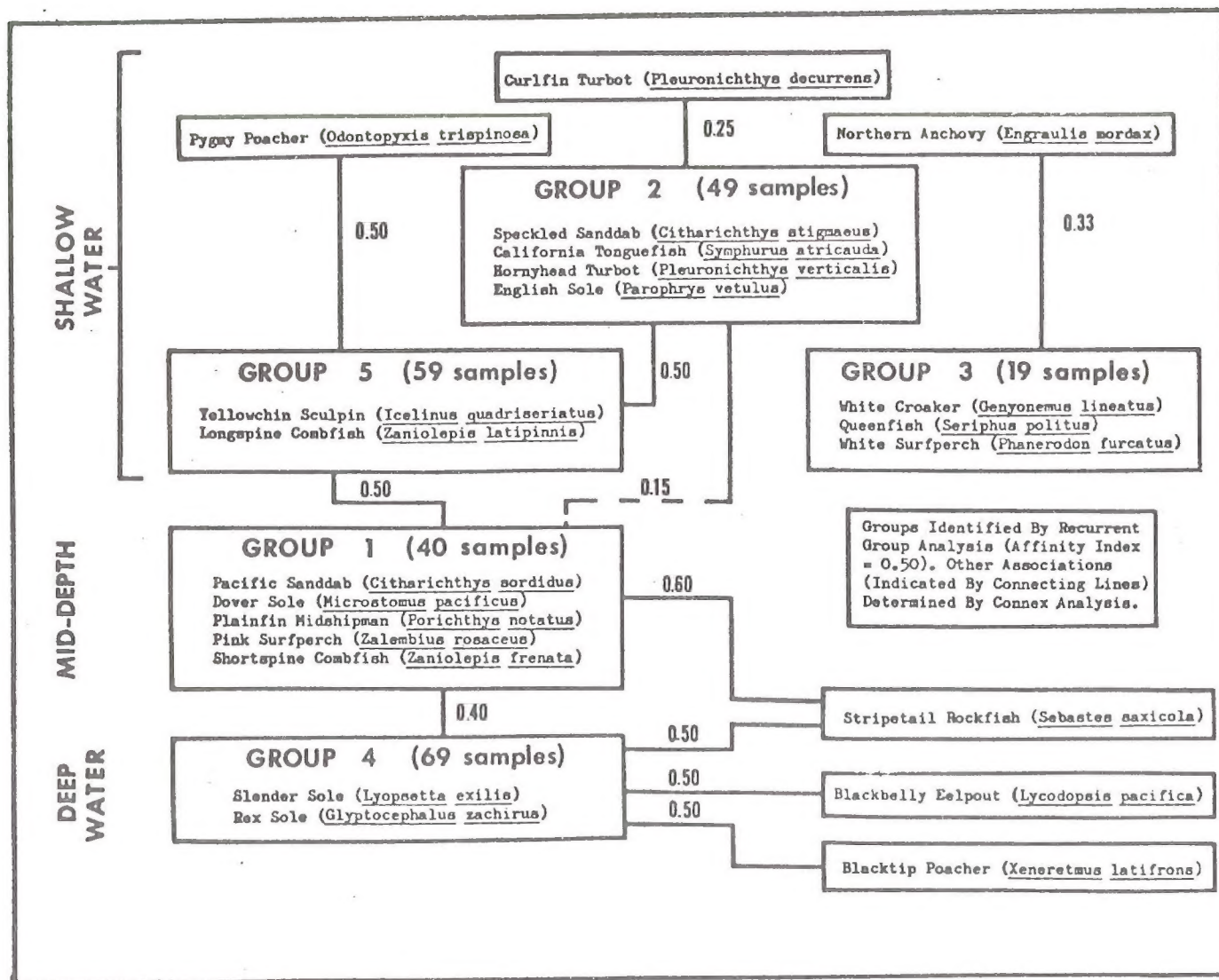


Figure 55. Species associations of southern California nearshore demersal fishes, 1969-1972. (after SCCWRP, 1973a).

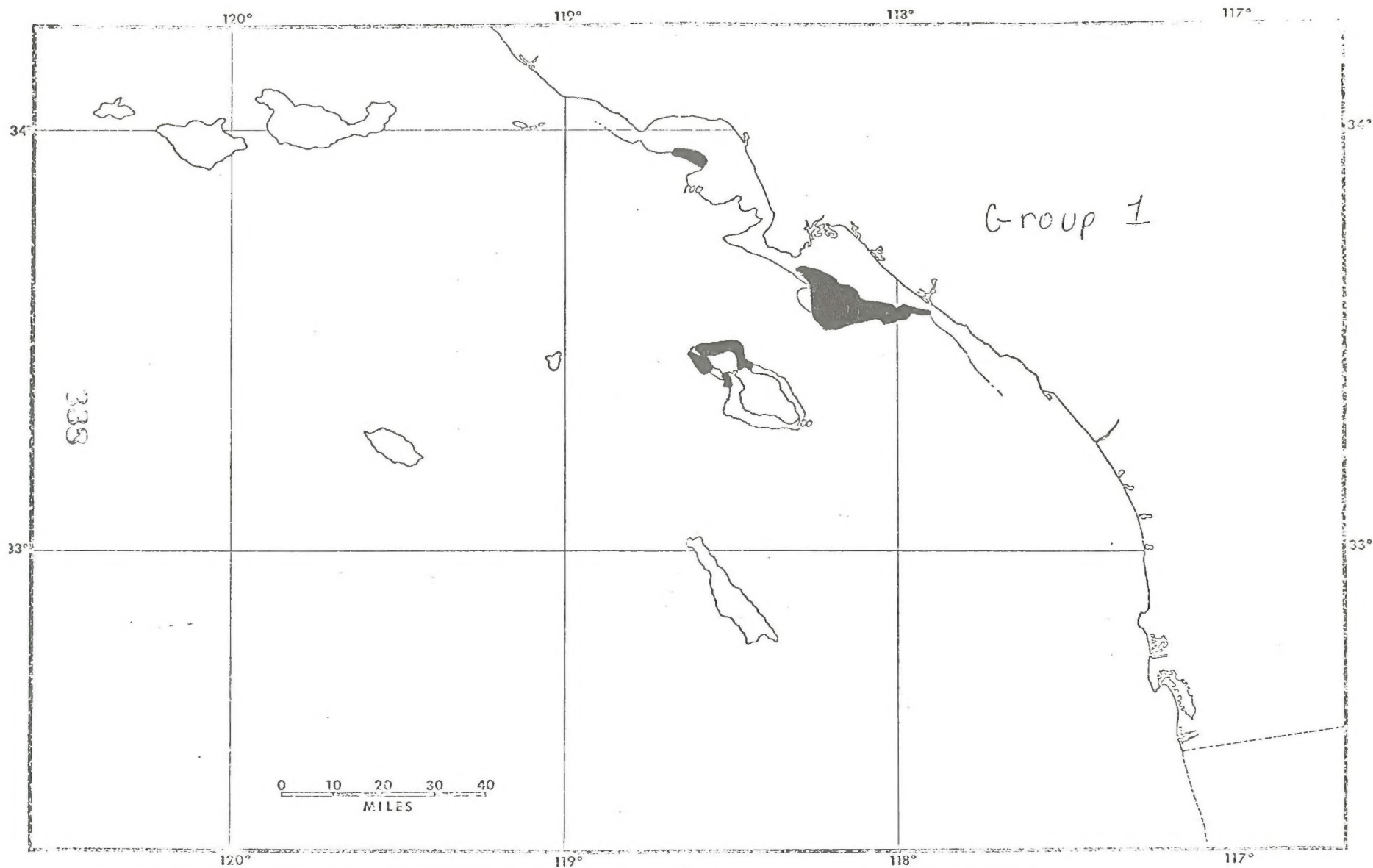


Figure II-56A. Distribution of recurrent groups of Southern California nearshore demersal fishes, 1969-72 (after SCCWRP, 1973a). (Depth line 100 m). Group 1.

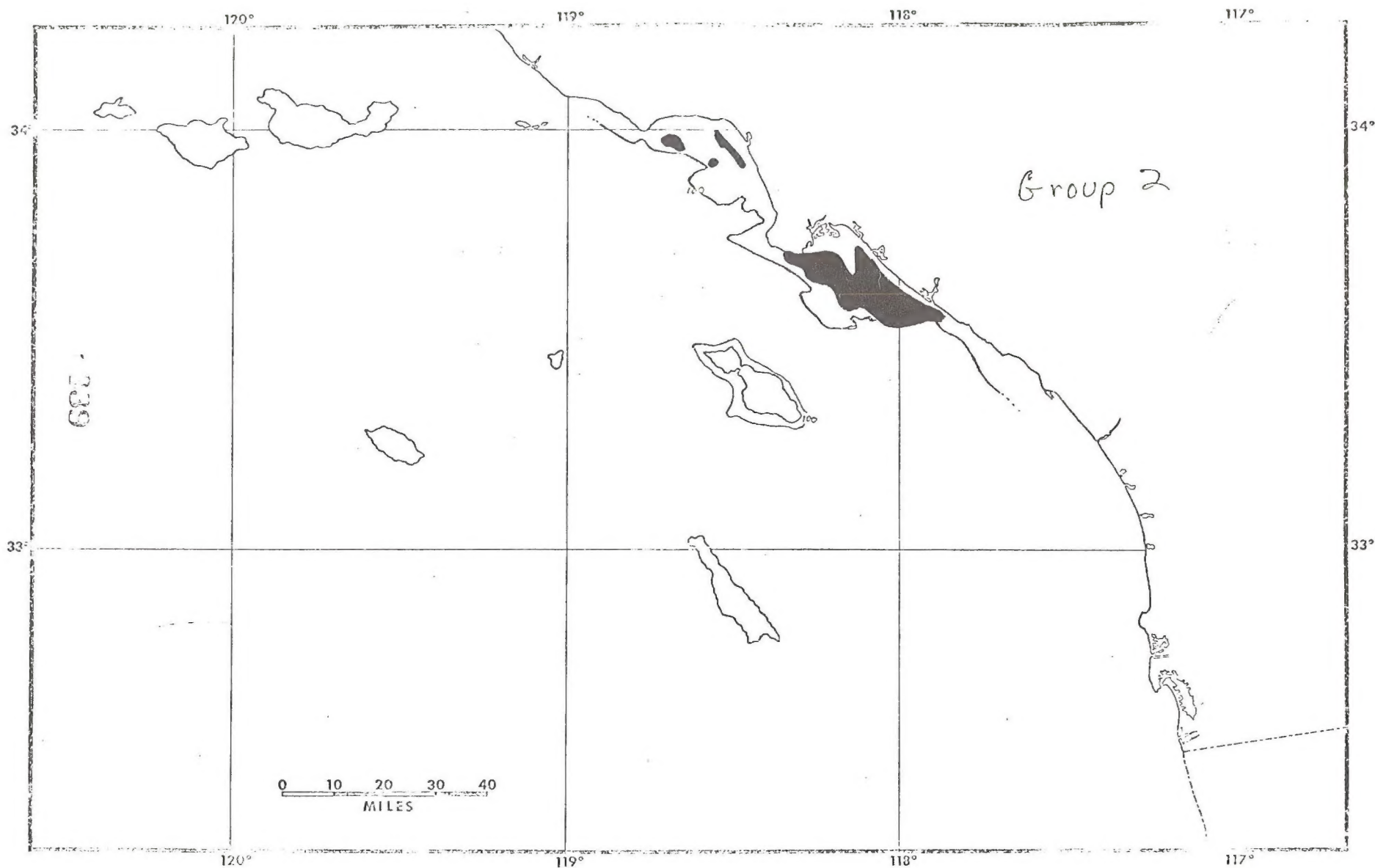


Figure II-56.b Distribution of recurrent groups of Southern California nearshore demersal fishes, 1969-72 (after SCCWRP, 1973a). Depth line 100 m). Group 2.

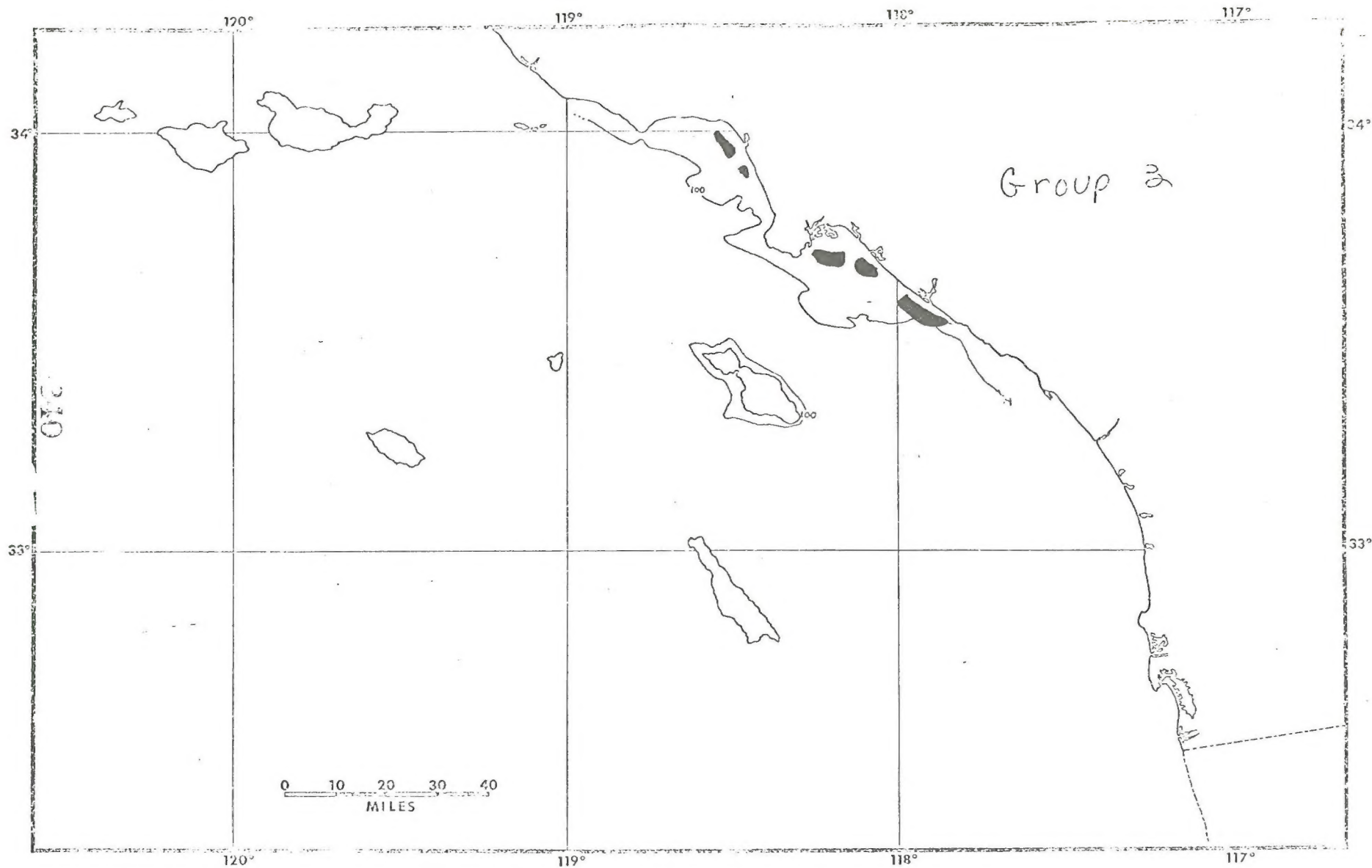


Figure II-56. c Distribution of recurrent groups of Southern California nearshore demersal fishes, 1969-72 (after SCCWRP, 1973a.). (Depth line 100 m). Group 3.

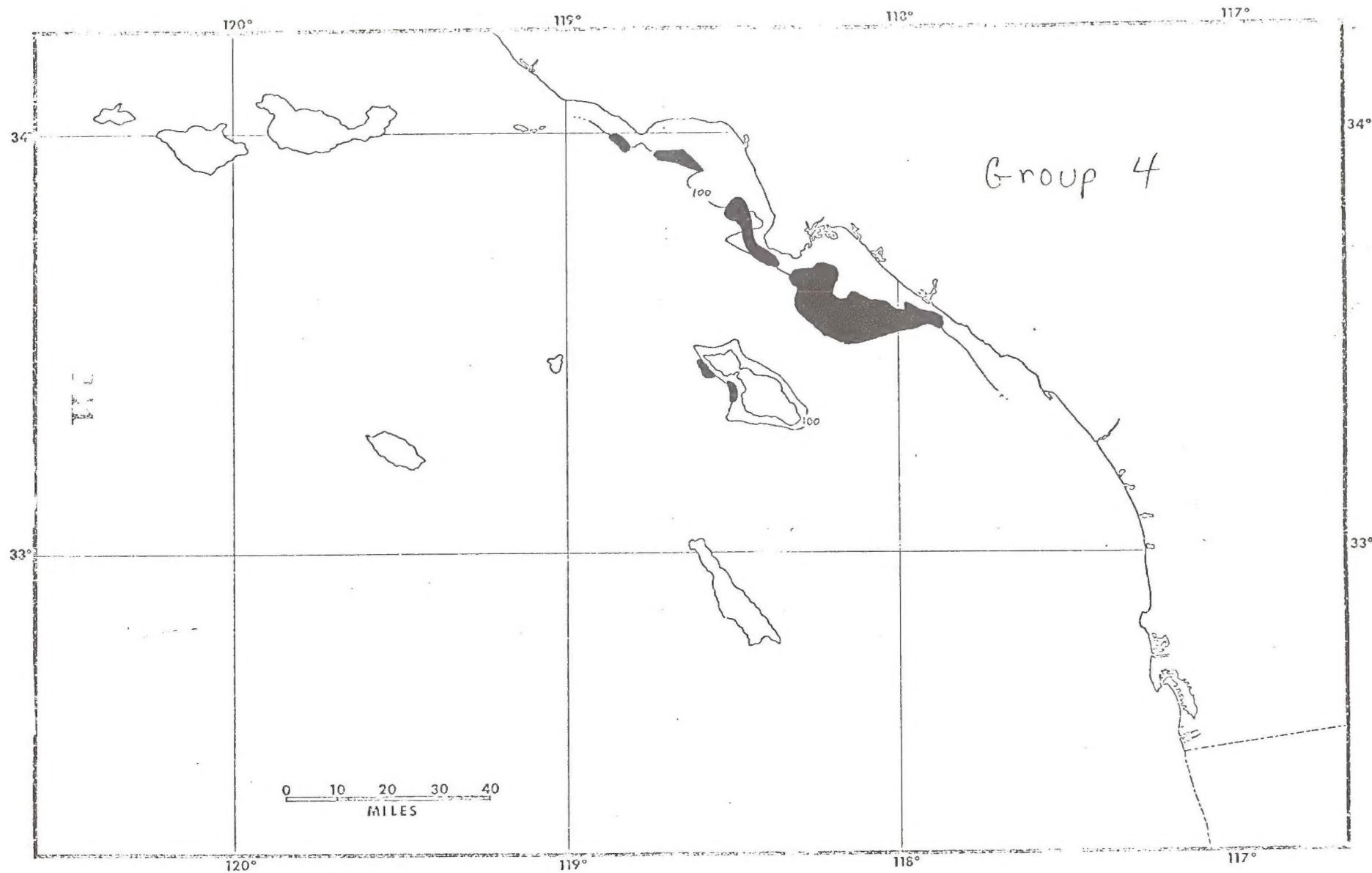


Figure II-56.d Distribution of recurrent groups of Southern California nearshore demersal fishes, 1969-72 (after SCCWRP, 1973a.). (Depth line 100 m). Group 4.

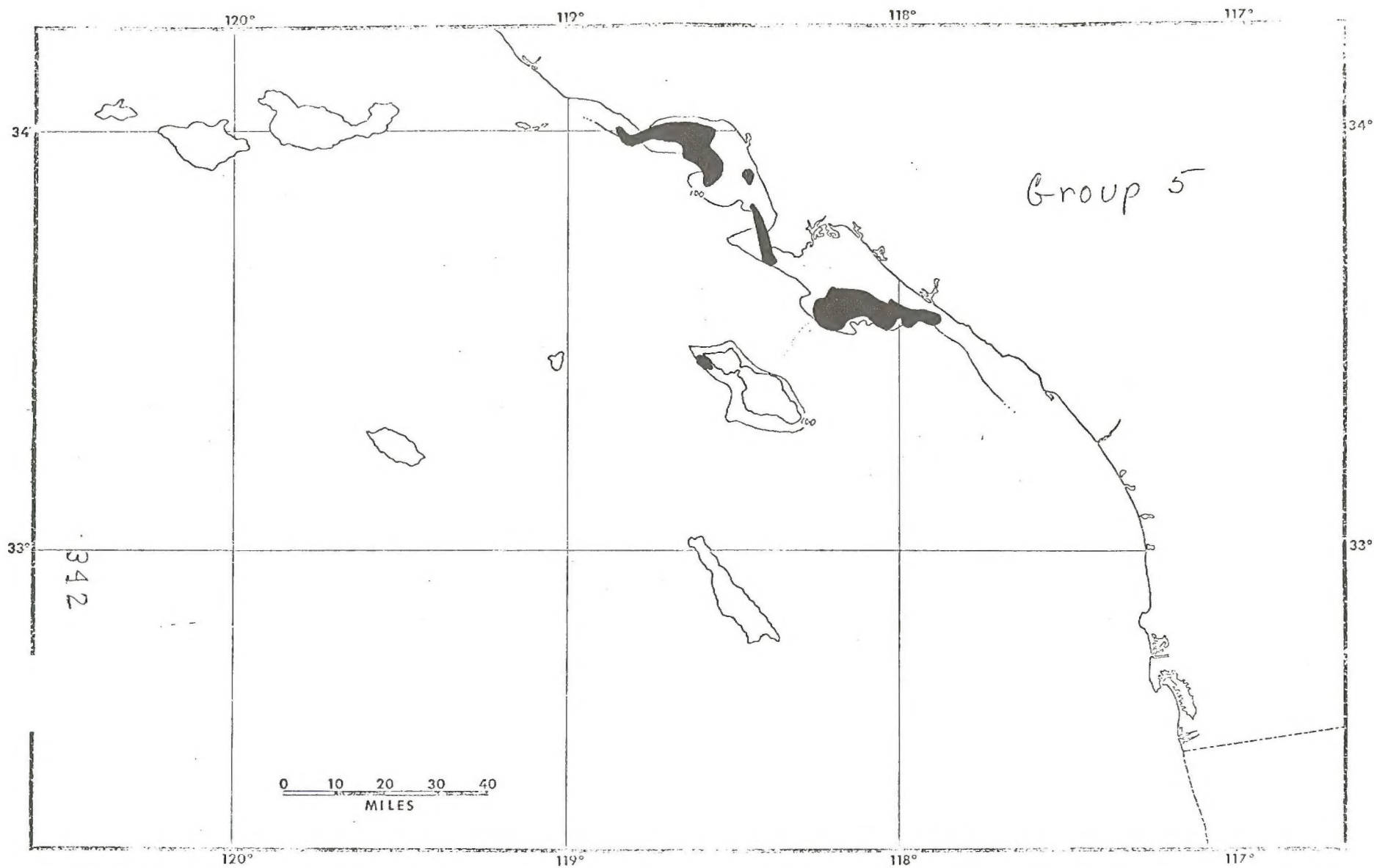


Figure II- 56. e Distribution of recurrent groups of Southern California nearshore demersal fishes, 1969-72 (after SCCWRP, 1973a.) (Depth line 100 m). Group 5.

situ photography. However, the recurrent group analysis completed by SCCWRP does, at a minimum, identify species that are very frequently found together in nature and that therefore apparently select similar environmental conditions. Similar recurrent group analysis are not available for other particular habitats in the shelf environment.

iv. Food Habits and Trophic Relationships

Detailed studies of food habits have been conducted on relatively few coastal shelf fishes in Southern California. General notes on food and feeding of many species appear in the literature but information on selectivity and relative composition of food is lacking so that a complete picture of trophic relationships is not available. Food habits by major category of shelf fish families are included in Table E.4-1 **App. 10, E.4**). One of the most exhaustive studies of food habits of Southern California fishes has been conducted by Quast (1968 c and d) on 45 species associated with kelp beds. Turner, Ebert, and Given (1969) compiled information on the stomach contents of 14 species associated with man-made reefs. Pinkas, Oliphant, and Iverson (1971) reported in depth on the food habits of three scombrids, albacore (*Thunnus alalunga*), bluefin tuna (*Thunnus thynnus*) and Pacific bonito (*Sarda chilensis*). Food of the Pacific sardine (*Sardinops caeruleus*) has been studied by Han and Berner (1959) and of the California yellowtail (*Seriola dorsalis*) by Baxter et al. (1960). Fitch and Lavenberg (1971) and Frey (1971) have listed general information on food habits of several commercially important and otherwise common fishes in Southern California.

A survey of the literature indicates that the northern anchovy

(*Engraulis mordax*) occupies a central and important position in the trophic structure of Southern California waters. They are pelagic schooling fish and one of the most abundant species in the region (Smith, 1972). Anchovies have been considered to be indiscriminate, chiefly daytime, filter feeders accepting either zooplankton or phytoplankton but also feeding on small fishes (Frey, 1971). However, Loukashkin (1970) showed that zooplankton was usually far more abundant than phytoplankton in anchovy stomachs and concluded that large copepods and euphausiids were the most important food items. According to Frey (1971) anchovies along with squids, red crabs and lantern fishes are preyed upon heavily by most predatory species in California waters. Similarly, Baxter (1967) stated that qualitative studies show anchovies to be an important constituent in the diets of all the large predatory game fishes off California. In a quantitative study, Pinkas, Oliphant, and Iverson (1971) showed that anchovies constitute 76% of the bonitos diet, 56% of the albacores diet when the albacore is in Southern California waters, and 80% of the diet of bluefin tuna when the tuna is in Mexican and California waters. Pinkas, Oliphant, and Iverson concluded that the role of the northern anchovy is singularly outstanding as the dominant food item for three important sport and commercial fishes along the Southern California coast.

A series of recent laboratory studies on the anchovy conducted mainly at the Southwest Fisheries Center in LaJolla has added significantly to the knowledge of the feeding behavior of this important species. Leong and O'Connell (1969) showed that the anchovy captured

brine shrimp (*Artemia*) nauplii (0.65 mm long) by filtering, but captured the much larger *Artemia* adults (3.7 mm long) individually by directed biting (particulate feeding) when each food was presented separately. Food biomass was accumulated more rapidly by biting than filtering. They hypothesized that the anchovy could not sustain its daily food requirements by filtering alone off Southern California except in limited areas of heavy plankton concentration. O'Connell (1972) found that the ratio of biting to filtering activity in small schools varied with the relative concentration of *Artemia* adults and nauplii in the water.

Ratios of large-to-small crustaceans are relatively high near the surface at night off Southern California, which suggests that biting activity could often exceed 50% of total feeding activity. If plankton does support a high percentage of biting activity, a large part of the area should usually provide the anchovy with its daily nutritional needs. Hunter (1972) in an analysis of the swimming and feeding behavior of larval anchovy calculated that larvae just after yolk absorption requires up to 37 times the food density as older larvae. Thus, just after yolk absorption anchovy larvae are more vulnerable to death from starvation than at any other time during the larval stage. Finally, Lillielund and Lasker (1971) showed that a variety of marine copepods including species common to surface waters of the California Current fatally injure and ingest young anchovy larvae in the laboratory. They offered the opinion that certain predatory copepods and fish larvae are concentrated in the upper few meters and probably the upper few centimeters of the sea and that observations of this oceanic fine structure may reveal densities of fish larvae to copepods which would implicate

predatory copepods (and possibly other zooplankters) as important causes of larval fish mortality.

v. Reproduction and Early Life History

Reproductive and general life history studies have been mostly confined to certain of the commercially important and/or abundant shelf species. Studies or summaries of knowledge on individual species include those by Bable (1967) on the round stingray (*Urolophus halleri*), Clark (1929) on jacksmelt (*Atherinopsis californiensis*), Walker (1952) on grunion (*Leuresthes tenuis*), Baxter (1967) and MacGregor (1966) on jack mackerel (*Trachurus symmetricus*), Hagerman (1952) on dover sole, Wales (1952), Phillips (1964), and Moser (1966, 1967, 1972) on rockfishes (*Scorpaenidae*), Smith and Young (1966) on kelp bass (*Paralabrax clathratus*), Baxter (1960) on California Yellowtail (*Seriola dorsalis*), Walford (1932) on California barracuda (*Sphyraena argentea*), O'Connell (1953) on cabezone (*Scorpaenichthys marmoratus*), Carlisle, Schott and Abramson (1960) on the barred surfperch (*Amphistichus argenteus*), Turner and Ebert (1962) on the blacksmith (*Chromis punctipinnis*), Ebert and Turner (1962) and Wiley (1970) blue-spot goby (*Coryphopterus nicholsi*), and by Clarke (1971) on the garibaldi (*Hypsypops rubicundus*). Fitch and Lavenberg (1971) have provided general information on the reproductive and life history of several of the more common food and game fishes in California including southern waters. Frey (1971) summarized the reproductive and other biological information on California fish species comprising the principal part of the marine fish resources in California. Table E 4-4 (App. 10, E.4) is a compilation of data from Frey (1971) on the type of reproduction, age and size at maturity, number of eggs or young, and on spawning season and locality for 33

species which reproduce in Southern California waters.

A recent experimental study by Leong (1971) has resulted in the induced spawning of the northern anchovy in the laboratory. Anchovies were induced to mature their gonads by an artificial photoperiod of 4 hr light and 20 hr darkness at 15°C. Two injections, a first of human chorionic gonadotropin (HC G) and the second 2 days later of either salmon pituitary or carp pituitary, induced spawning. At each spawning 6,000 to 16,000 eggs were collected, and 25 to 80% of the eggs hatched. Larvae grown from these eggs were morphologically similar to those caught in the sea.

Data on relative abundance and horizontal and vertical distribution are available on the eggs and larvae of certain of the principal shelf species and have largely been accumulated by longterm studies at what is now the National Marine Fisheries Service Southwest Fisheries Center in LaJolla. The emphasis at this laboratory has been mainly on offshore pelagic fishes particularly in the California Current region, and less so on nearshore species. Very little information is available on either the reproduction or early life history of bay or estuarine-oriented fishes.

Ahlstrom (1959) in a study of the larvae off Southern California and Baja California found that most of both were found to occur in the upper mixed layer and in the upper part of the thermocline between the surface and approximately 125 m deep. The northern anchovy was the most abundant larvae collected and comprised 33 to 44% of the total larvae in three tabulations. Larvae of four fishes which were then (1959 and prior) of considerable commercial importance - Pacific

mackerel (*Scomber japonicus*), jack mackerel, Pacific sardine and northern anchovy - had the shallowest depth distributions of any of the more common kinds sampled. Between 79 and 99% of the larvae of these species occurred above 50 m. Larvae of another common species, Pacific hake (*Merluccius productus*), occurred in greatest abundance within or below the thermocline (mainly 50 - 100 m). Rockfish larvae were taken within or above the thermocline (upper 100 m). Sanddab larvae (*Citharichthys* spp.) were taken between the surface and 88 m. Anchovy and sardine larvae were four to five times as abundant in night collections as in day ones.

Larvae of northern anchovy and Pacific hake were consistently the most abundant in CALCOFI surveys from 1955 to 1958 (Ahlstrom, 1965). Other abundant larvae of shelf fishes in the 1955 to 1958 surveys included those of *Sebastes* spp., *Citharichthys* spp., *Sardinops caeruleus*, and *Trachurus symmetricus*. Ahlstrom (1965) stated that if only the larvae of the 25 most common kinds of fishes (including those of deep-sea families) were known, for example, a name could be given to 19 out of every 20 larvae collected in the California Current surveys, or, in other words, these kinds make up most of the larval biomass.

The horizontal distribution of larvae of Pacific hake, *Sebastes* spp. and *Citharichthys* spp. showed medium to dense concentrations in the Southern California Bight in the 1955-58 CALCOFI survey (Ahlstrom, 1965). Jack mackerel larvae were concentrated further offshore and more in the immediate area of the California Current. Larvae of Pacific sardine and northern anchovy have historically co-occurred in the Bight and California Current but the recent trend (as mentioned earlier for the adults)

has been for the anchovy to replace the sardine and as Ahlstrom (1967) stated, anchovy larvae now seem to be completely dominant. Smith (1972) in a more recent paper, reiterated this trend and estimated the spawning biomass of anchovies to be perhaps 1000 times larger than that of the sardine.

vi. Special Habitats - Kelp Beds

The kelp beds in Southern California waters provide a distinct and important habitat for fishes and it has been generally concluded that giant kelp encourages the development of a rich associated fauna. The fishes of the beds are considered to be the primary animal resource. Present knowledge of the diets, behavior, preferred habitats, abundances, and life histories comes largely from a series of studies by Quast (1968 a, b, c, d, and e) published in a fish bulletin edited by North (1971). Kelp serves as a food source, as shelter, and an attractant for fishes, but it was found not to be a habitat requirement for most fishes nor did it increase species diversity significantly. It contributes to greater standing crops of fishes but, bottom topography was considered a more important attractant.

Quast (1968b) listed 57 species as being associated with kelp beds and these are given in Table 11-4 in Horn (1974). Quast (1968c) arrived at a mean value for standing crop of resident kelp-bed fishes of 313 pounds/acre.

Kelp bass (*Paralobrax clathratus*), California sheephead (*Pimelometopon pulchrum*), and blacksmith (*Chromis punctipinnis*) were the most frequently encountered species in kelp beds of the San Diego region. At the northern region of the California Bight near Point Con-

ception off Gaviota were kelp bass, topsmelt (*Atherinops affinis*), and kelp perch (*Brachyistius frenatus*). Within the Southern California area community dominance changes, the kelp bass being the only dominant at both northern and southern extremes of the area.

Quast (1968 c and d) made an extensive study of the food habits of 45 species of kelp bed fishes and his data on food items are incorporated in Table E 4-1, (App. 10, E.4) which gives major food items of fish families. Based on a utilization index calculated by Quast (1968d) the five main food items of kelp-bed fishes are 1) gammarid amphipods, 2) crabs 3) algae, 4) shrimp other than pistol shrimp, and 5) polychaetes. Thirty-three other food categories were listed by Quast.

The effects of periods of decline of the kelp-beds on the diversity, composition and abundance of the rocky inshore fish fauna are briefly discussed in the last section of this chapter.

vii. Special Habitats - Semi-Enclosed Bays

The bays considered here are those with restricted openings to the ocean and include Mission Bay, Newport Bay, Anaheim Bay and Alamitos Bay. These are distinguished from the more open coastal regions frequently designated as bays such as San Pedro Bay and Santa Monica Bay which in this report are included as part of the mainland shelf proper.

Although the semi-enclosed bays and estuaries are nearshore and in proximity to human activity and generally considered to be important as nursery grounds for fish eggs and larvae, surprisingly little information is available on their fish fauna. Data on distribution, seasonality, trophic relationships, reproduction, and relative importance as nursery

grounds are scattered and incomplete. No complete published lists of eggs and larvae are available for the bays or estuarine areas. More information is available on, for example, larval distribution and trophic relationships of deep basin fishes than for bay and estuarine populations which reflects the emphasis of study but also the lack of knowledge of the latter habitats.

The extent of information is largely represented by tentative species lists. Chapman (1963) provided a list of 77 species known from Mission Bay. Bane (1968) published a brief account of fishes from Newport Bay, and Frey, Hein, and Sprvill (1970) provided a checklist with qualitative information on relative abundance of 63 species that occur in Newport Bay. Reish (1968) included an illustrated list of fishes in his booklet on Alamitos Bay. Haaker (1971) during the course of an investigation of the life history of the California halibut (*Paralichthys californicus*) in Anaheim Bay compiled a list of 34 species taken in trawls with the halibut. Larry Allen (personal communication) during recent work on the upper arm (Colorado Lagoon) of Alamitos Bay has increased the number of species known from that bay to 44.

A few studies have been completed on life history aspects of fishes that frequent bays and include those by Bable (1967) on the round stingray (*Urolophus halleri*), by Bane and Robinson (1970) on the shiner perch (*Cymatogaster aggregata*) in upper Newport Bay, and by Haaker (1971) on the California halibut in Anaheim Bay.

Studies on fish population in Anaheim Bay are currently under way at California State University, Long Beach and studies on larval and adult fishes in Newport Bay have recently been initiated at California State University, Fullerton.

viii. Special Habitats - Man-Made Habitats

The Southern California marine region is adjacent to a major population center and in the course of human activity both incidental and deliberate processes have either provided habitats previously absent or have altered existing ones. The following two subsections treat 1) harbors and, 2) other artificial structures as special fish habitats.

Harbors formed by breakwaters constructed by rock or other hard material slow the water movement and affect other changes which make them in some ways similar to semi-enclosed natural bays (i.e., protected from the open ocean) and which makes it possible to recognize them as distinct fish habitats. Two harbor areas in Southern California are currently being studied with regard to their fish fauna. These are King Harbor at Redondo Beach and Los Angeles - Long Beach Harbor. Table 11-9 in Horn (1974) lists the species that have been observed or collected in recent diving, trawling, and other surveys.

Studies based on five years of diving observations by John Stephens and his students at Occidental College show that King Harbor is extremely rich in number of species (82 species listed in Table 11-9 in Horn, 1974). Stephens (1972) has suggested that much of the faunal richness may be associated with thermal diversity supplementing the newly created man-made heterogeneity of the harbor. The varied temperature regime according to Stephens is due to hot water effluent from the Edison plant and cold upwelling from Redondo Canyon.

Chamberlain (1974) compiled a list of 126 species in 48 families that have been recorded from the harbor (Table 11-9 in Horn, 1974).

Based on 76 trawls made in the harbor, Stephens, et al. (1974) found that the fish density was the highest recorded locally (one fish/8.9 m²) and that diversity and richness approximated values recorded for similar depths outside the harbor. The 11 most abundant species in the harbor, according to Stephens, et al. (1974), are white croaker (*Genyonemus lineatus*), northern anchovy (*Engraulis mordax*), California tonguefish (*Symphurus atricauda*), speckled sanddab (*Citharichthys stigmaeus*), queenfish (*Seriphus politus*), shiner surfperch (*Cymatogaster aggregata*), white surfperch (*Phanerodon furcatus*), specklefin midshipman (*Porichthys myriaster*), bay goby (*Lepidogobius lepidus*), vermilion rockfish (*Sebastes miniatus*) and hornyhead turbot (*Pleuronichthys verticalis*). Anchovies and young white croakers, which made up 69% of the catch, are plankton feeders, and their abundance probably reflects the nutrient enrichment of the harbor. A greater abundance of fishes was found in summer than in winter. Stephens, et al. (1974) estimated the standing crop of fishes in the harbor to be between 700,00 and 1,600,000 kg and the annual productivity at 56% of the standing crop or 392,000 - 896,000 kg (7.3 - 16.5 g/m²).

Los Angeles - Long Beach Harbor is an assemblage of various substrates including sandy-mud bottom, rocky bottom, rock and concrete breakwaters, wood and concrete pilings, sandy beaches, estuaries, and small islands and has an average depth of approximately 37 ft (Chamberlain, 1974). Stephens, et al. (1974) were able to recognize three areas of distribution within the harbor: an area rich in flatfishes; and area of high croaker abundance; and an area demarcated by the presence of rockfishes. The area rich in croakers seems to correlate with nutrient enrichment (sewage) and perhaps low oxygen tension.

An understanding of the ecology (including trophic position, niche specialization, and competition) of most harbor species is in the initial stages.

ix. Special Habitats - Other Artificial Structures.

Two studies that have dealt with artificial structures as habitats for shelf fishes of Southern California are those by Carlisle, Turner, and Ebert (1964) and Turner, Ebert and Given (1969). The former in a period from May 1958 to December 1960, observed a total of 86 species of fish around a variety of artificial structures including offshore oil drilling installations and reefs composed of deliberately placed car bodies, a streetcar, quarry rock, and concrete shelters. All structures appeared to serve as fish attractants. Populations grew from a few scattered fishes to several thousand semi-residents. Deeper water towers attracted pelagic schooling fishes and several species of rockfish not associated with the inshore areas. Typical species of inshore sites were kelp fishes (Clinidae), croakers (Sciaenidae), and small sharks. In both areas surfperches (Embiotocidae) were the dominant fishes. The study by Carlisle, Turner, and Ebert was made in response to kelp-bed decline and on the premise that thigmotropism (i.e., response to touch), schooling behavior, shelter and food are important factors in the success of reefs, artificial or otherwise. They reported that changes in habitat brought about by establishing offshore oil drilling installations were generally beneficial in that they served to attract fishes. However, fish populations at the artificial sites increased rapidly for the first year and then exhibited fluctuations apparently correlated to temperature, season, or other

natural factors.

In a continuation of the above study Turner, Ebert, and Given (1969) studied artificial reefs composed of quarry rock, a streetcar, 14 automobile bodies and 44 concrete shelters over a 4 plus year (August 1960 to January 1965). Concrete shelters attracted the largest number of fishes and in all, 78 species in 35 families were recorded. These fishes are listed in Table 11-4 in Horn (1974). Surfperches and serranid basses were dominant during the first two years of reef life and with time decreased in dominance while resident species such as cottids, gobies, damselfish and others increased. Within about five years a natural situation was reached and the plant and animal populations exhibited fluctuations typical of reef ecosystems. The authors concluded that the artificial reefs can be made into productive fishing areas with fishing success on the reefs two to three times that recorded for nearby natural reef areas.

c. Fishes of the Deep-Sea Basins

Many species of deep-sea fishes are periodically found because of their vertical migratory activity in the upper layers of the ocean (upper 100-150 m - the epipelagic zone); however, they are members of a rather distinctive fauna which lives part or all of its life in waters several hundred to 1000 or more meters deep. These "deep-sea" fishes are generally small (300 mm long), black or dark with silvery reflective sides and frequently with luminescent organs.

i. Distribution and Seasonality

The midwater (deep-sea) fauna off Southern California is especially complex because it contains species from three

converging water masses as well as species endemic to the California Current system (Lavenberg and Ebeling, 1967; Ebeling, et al. 1970b). The water masses are (1) Pacific Subarctic (northern) water which influences the shallow layers of the basins, (2) North Pacific Central (west Central) water which may influence the intermediate layers and (3) Pacific Equatorial (southern) water which influences the deep layers of the deeper basins (Lavenberg and Ebeling, 1967). Water masses of the Southern California borderland are derived from three sources and frequently referred to as "transitional waters". A counterclockwise current gyre, extending from the point of offshore deflection of the California Current at Point Conception to south of the Mexican border, moves inshore during a period of upwelling in spring and early summer (Brown, 1969). Here, some 13 depressions pit the relatively narrow continental shelf.

All basins have mesopelagic fishes (active, silvery fishes typical of the 150-1000 m depth interval) whereas only the deeper basins have a developed bathypelagic fauna (sluggish, black fishes typical of deep midwaters deeper than 800-1000 m but sometimes as shallow as 500 m). For example, Santa Barbara Basin is shallow, contains no southern water and, therefore, has no true bathypelagic zone; whereas Santa Cruz is deep, contains southern water, and a more diverse bathypelagic fauna (Lavenberg and Ebeling, 1967). In general, the diversity of the mesopelagic and bathypelagic faunas increases with vertical expansion of their habitats offshore. According to Ebeling, et al. (1970a) both resident and transient species occur and assert themselves both by depth and by basin.

Paxton (1967) in a distributional analysis of 14 species of lanternfishes (Myctophidae) in San Pedro Basin found that horizontal distributions mainly coincided with water mass distributions in the North Pacific and recognized five distributional patterns for the fishes. He indicated that temperature and light were the most important ecologic determinants of vertical distribution and that the shallow thermocline restricts the nocturnal distribution of eight species. Paxton reported geographic variation in vertical species composition patterns. In the San Pedro Basin the entire or most of the populations of 10 species migrate to above 150 m every night. Many more lanternfishes were taken in the winter months (November - March) than in the summer (June - August), presumably due to active or passive horizontal migrations into and out of the basin.

DeWitt (1972) studied the vertical distributions of two common deep-sea fishes, *Cyclothone acclinidens* (a bathypelagic species) and *C. signata* (a mesopelagic species) (family Gonostomatidae) in the Southern California basins. He found distinct morphological and behavioral adaptations of the two species to their respective environments. *C. signata* lives in a comparatively complex, variable, bright, warm, and food-rich environment and is characterized by disruptive coloration, a gas-filled swimbladder, and a selective feeding mechanism. In contrast, *C. acclinidens*, from a more homogeneous, stable, cold, dark, food-poor environment where oxygen is at a minimum, has a black skin, a fat-filled swimbladder, a non-selective feeding mechanism, and large gills for increased oxygen uptake in an oxygen-minimum layer.

Ebeling et al. (1970a) proposed a four-dimensional spatial and

temporal model of the deep pelagic ecosystem off Santa Barbara with four resident communities basic to its organization. The resident communities are for the most part unaffected by local water mass changes. Transitory species move within and about the fundamental framework of communities and often form relatively unstable groups by their different kinds of daily and seasonal movements. Many are either the young of shelf species or offshore species whose centers of distribution are distant from the local area. Seasonal changes in currents and transport from these outlying regions could account for annual or long-term populations and community changes. This idea is supported by data from Ebeling et al. (1970b) who cite several deep-sea species including the lanternfishes *Smbolophorus californiensis*, *Lampanyctus ritteri*, *Ceratoscopelus townsendi*, *Electrona rissoi*, *Notolychnus valdiviae*, and *Notoscopelus resplendens*, as possible expatriates (i.e. fishes wafted by currents into the area from their normal reproductive ranges). The above information illustrates the complex and dynamic character of the deep-sea fish fauna in Southern California basins.

i i. Diversity, Abundance, and Principal Species

The heterogeneity and transitionality of the Southern California deepwater environment result in a relatively diverse fish fauna for the region. Table 11-10 in Horn (1974) list 30 families and 93 species of midwater meso-, bathy-, and benthopelagic fishes. Benthopelagic applies to fishes such as Macrouridae and Brotulidae, which swim actively near the bottom of the deep ocean. More nearly benthic fishes include the Zoarcidae. The list was compiled primarily from Ebeling et al. (1970b) and Miller and Lea (1972). To arrive at a single,

reliable figure for the number of species of deep-sea fishes is both difficult and somewhat artificial because of the transitional and dynamic character of the environment and its fish communities. Miller and Lea (1972) listed 48 primarily meso- and bathypelagic forms and stated that the number represented about one-quarter of all such California (not just Southern California) species. Fitch and Lavenberg (1968) provided a species list of deep water species (260 species in 71 families) but, again, they include fishes from all of California's deep waters. Ebeling et al. (1970b) pointed out that of the fishes in their analysis of ecological groupings of deep-sea animals off South California, 60% were mesopelagic although the mesopelagic occupied only 33% of the target environment. The remaining 40 % of the species were divided among the bathypelagic and benthonic (benthopelagic and benthic) adaptive zones.

Fitch and Lavenberg (1968) felt that two deep-sea families, the Myctophidae and Gonostomatidae, are the two most abundant fish groups in the world oceans. This generalization probably holds for Southern California waters. The five principal deep water families for the region in terms of number of species are 1) Myctophidae, 16 species; 2) Melamphaeidae, 9 species; 3) Sternotychidae, 7 species; 4) Gonostomatiade, 6 species; and 5) Bathylagidae, 5 species (see Table E4-1). The species most frequently encountered by Ebeling et al. (1970a; 1970b) were *Leuroglossus stilbius*, a mesopelagic bathylagid, and two mesopelagic myctophids, *Stenobrachius leucopsarus* and *Triphoturus mexicanus*. Paxton (1967) also concluded that *S. leucopsarus* and *T. mexicanus* were the predominant myctophids in this study.

Based on studies of larval distribution and abundance in the California Current region, Ahlstrom (1955, 1965, 1969) has shown that three deep-sea pelegic families, the Bathylagidae, Gonostomatidae, and Myctophidae, contribute significantly to the total of all fish larvae collected. During the 1955-1960 CALCOFI surveys, individuals of the above three families made up 18 to 43%, depending on the year, of all larvae captured (Ahlstrom, 1969). In a summary of relative abundance of larvae in 1955-1958 CALCOFI surveys (Ahlstrom, 1965), four deep-sea species in the above three families consistently ranked among 12 most abundant larvae collected. *Leuroglossus stilbius* ranked 5th three different years and 12th one year. *Vinciguerrria lucetia* (Gonostomatidae) ranked 3rd twice and 9th twice and the myctophids, *Triphoturus mexicanus* and *Stenobranchius leucopsarus* ranged from 5th to 10th in abundance in the four-year period.

iii. Species Associations

Information on species associations and ecological groupings of deep-sea fishes in Southern California waters comes primarily from studies by A. W. Ebeling of the University of California, Santa Barbara, and his co-workers and students. The principal studies include those by Paxton (1967), Lavenberg and Ebeling (1967), Brown (1969), Ebeling, et al. (1970a and 1970b).

Paxton (1967a) discovered repetitive co-occurrences in both the horizontal and vertical distribution patterns of certain species of lanternfishes in the San Pedro Basin. He found that horizontal distributions of basin lanternfishes coincided with water mass distribution in the North Pacific and recognized five distributional

patterns: 1) Subarctic-Transitional, represented by *Tarletonbeania crenularis*, *Diaphus theta*, *Stenobrachius leucopsarus*, and *Lampanyctus ritteri*; 2) Transitional, represented by *Symobolophorus californiensis*, *Lampadena urophaos*, and *Parvilux ingens*; 3) Subarctic-central Pacific by *Protomyctophum crocheri* and *Lampanyctus regalis*, 4) Eastern Equatorial by *Diogenichthys laternatus*, *Triphoturus mexicanus* and *Scopelengys tristis*; and 5) Cosmopolitan, represented by *Diogenichthys atlanticus*, *Taaningichthyes bathyphilus*, and *Ceratoscopelus townsendi*. Paxton recognized from open net captures five patterns of vertical distribution. Diurnally all species studied were taken below 350 m in the basin, with the center of concentration between 450 and 700 m. Five species were centered below 650 m and ten species above 650 m. Nocturnally, two of the deep species *Taaningichthyes bathyphitus* and *Scopelengys tristis* did not migrate and three (*Lampadena urophaos*, *Lampanyctus regalis*, and *Parirlux ingens*) migrated to 50 m. Four shallow species (*Diogenichthys atlanticus*, *Symobolophorus californiensis*, *Diaphus theta*, and *Ceratoscopelus townsendi*) migrated into the upper 10 m, five (*Diogenichthys laternatus*, *Tarletonbeania crenularis*, *Stenobrachius leucopsarus*, *Triphoturus mexicanus*, and *Lampanyctus ritteri*) migrated to 50 m, and one (*Protomyctopham crockeri*) migrated to only 150 m. While Paxton's work did not reveal or show the significance of ecological groupings, it did show that certain species frequently co-occur and probably have at least some similar behavioral and ecological responses.

Lavenberg and Ebeling (1967) in a distributional study of deep-basin midwater fishes recognized groups of species associated with

the three main North Pacific water masses mentioned above. The northern component of the fish fauna comprised 32 species, most of which inhabit the mesopelagic zone where northern water predominates. The 76 southern species which were mostly bathypelagic and lower-mesopelagic, dominated the deep southern intrusions of equatorial water. The central component comprised only 16 species which were most abundant offshore where central waters invaded the mesopelagic zone. Multiple regressions of within-group abundances on a series of regularly measured environmental parameters indicated only a small percentage of the variability of most groups to be due to the regression. Lavenberg and Ebeling concluded that analysis of discrete depth samples taken in closing nets would resolve their recurrent ecological groups into smaller unit associations.

Ebeling, et al. (1970b) in a statistical analysis of ecological groups off Southern California showed that deep-sea fishes occur in patches either as random aggregations or well integrated shoals that vary temporally as well as spatially. Mesopelagic fishes clump more than bathypelagic species which undergo slight, if any, vertical migrations. Of the mesopelagic species with well developed light organs, hatchetfishes were most clumped, even more so than lanternfishes that ascended as part of a biological sound-scattering layer at night. The abundant fish, *Leuroglossus stilbius*, which lacks light organs but is countershaded ventrally, clumped somewhat less and dispersed upward during the night. They found that deep-sea animals including fishes, assemble into ecological groups which are somewhat confused within the mesopelagic zone because of interaction and overlap. Common species segregated into three groups: upper mesopelagic, mesopelagic, and

bathypelagic. *Leuroglossus stilbius* was distinguished from other common mesopelagic species by its extreme diurnal abundance at intermediate depths in the shallow inshore San Pedro Basin.

Species groups were found to segregate by location, trawl depth, capture frequencies, and capture ratios of mesopelagic to bathypelagic species. Santa Catalina Basin, of intermediate depth, supports a more diverse oceanic fauna than does the shallow inshore San Pedro Basin. Correlations of group abundance with environmental variables supported inferences from group structure that Southern California species assemble according to depth zones, zoogeographical centers of distribution, seasonal oceanographic fluctuations and vertical migratory behavior. Members of upper mesopelagic offshore transitional groups were most abundant over the borderland during early fall when water stratification and surface warming reached a maximum and intrusions of tropical waters from the west were detectable. The middle mesopelagic transitional group, on the other hand, abounded during periods of cool surface temperatures and vertical mixing. All growth stages of the two most common mesopelagic fishes, *Leuroglossus stilbius* and *Stenobrachius leucopsarus*, flourished in the eutrophic and rich shallow inshore basins and diminished numerically to seaward from a nearshore center of abundance. Ebeling, et al. (1970b) concluded that these two transitional species appeared best adapted of all to exploit the shallow productive nearshore waters.

iv. Food Habits and Trophic Relationships

A general picture has been developed of the food habits and trophic relationships of the principal species of Southern

California deepwater fishes. In certain aspects, there is a better understanding of trophic structure and energy flow in deep basin fishes than for inshore shelf fishes especially those of bays and estuaries. This is not to indicate that trophic ecology of the deep-sea fishes is well known for much information of a specific nature remains to be obtained.

Table E4-1 (App. 10, E.4) includes the food habits by major category of the deep-water families occurring off Southern California. Information on food habits comes mainly from the following papers: 1) Paxton (1967) on myctophids; 2) Collard (1970) on various species of midwater fishes; 3) DeWitt and Cailliet (1972) on two species of cyclothone (Gonostomatidae); and 4) Fitch and Lavenbert (1968), general notes on food and feeding of a number of deepwater fishes off California.

Paxton (1967) examined the stomach contents of nine lanternfish species (Stenobrachius leucopsarus, Lampanyctus ritteri, Triphoturus mexicanus, Symbolophorus californiensis, Diaphus theta, Tarletonbeania crenularis, Scopelogadus tristis, Ceratoscopelus townsendi, and Lampadena urophoas) and found crustaceans, particularly euphausiid shrimps, made up the main diet. Copepods, sergestid shrimp, and a few fishes (including two bathylagids, Leuroglossus stilbius and Bathylagus wesethi) were also found in the stomach. Lanternfishes appeared to consume large amounts of food at one time and to feed both during the day and at night.

Collard (1970) analyzed the stomach contents of 1087 specimens of 42 species of midwater fishes collected in the Eastern Pacific including several localities of Southern California. He concluded

that although various crustaceans (principally copepods and euphausiids) were the major dietary constituents comprising the forage of 95% of all specimens with indentifiable stomach contents, these deepwater fishes had diverse diets and were nonpreferential in their selection of prey. Collard disagreed with Paxton (1967b) in the level of food specificity of lanternfishes stating that they appeared not to be highly specific feeders, but rather opportunistic in their prey selection. Collard found both geographical and seasonal differences in the forage of the lanternfish, *Stenobrachius leucopsarus*, the most abundantly sampled species. Larger specimens of *S. leucopsarus* were found to feed on a wider variety of invertebrates than smaller, younger individuals.

DeWitt and Cailliet (1972) studied the feeding habits of Southern's California two abundant gonostomatid fishes, *Cyclothone signata*, a mesopelagic form, and *C. acclinidens*, a bathypelagic species. The recognizable material in *C. signata* stomachs was mainly copepods and some ostracods, the majority of both being shallow dwelling forms inhabiting the upper 200 m. Copepods, chaetognaths, ostracods, and amphipods comprised the recognizable contents of *C. acclinidens* stomachs. The appetite in the diet of *C. acclinidens* were predominantly deep-water forms distributed below 200 m. The diet of *C. acclinidens* appeared to be slightly more diverse than that of *C. signata* possibly due to the scarcity of food at deeper levels and the resulting necessity to be nonselective in feeding. DeWitt and Cailliet stated that *C. signata* probably feeds at all hours but mostly at shallow depths. Unlike lanternfishes which ascend only at dusk, this species may exploit the shallower depths at any time, then descend to a depth where it stops

feeding, becomes lethargic, and conserves energy prior to the next ascent. *C. acclinidens*, for an unknown reason, appear to feed mainly at night even though living in the uniformly cold and dark bathypelagic zone.

Some of the larger midwater fishes such as *Stomias atriventer* (Stomiatidae) and *Chauliodus macouni* (Chauliodontidae) feed on fishes and/or cephalopods (See Table E4-1) and a number of shelf and epipelagic fishes such as rockfishes and tunas feed to some degree on deep-sea fishes.

The Myctophidae, Bathylagidae, and Gonostomatidae are the most abundant deep sea fishes off Southern California and they assume central positions in oceanic food webs. Whales, seals, porpoises, seabirds, sharks, squids, salmon, yellowfin tuna, shipjack tuna, albacore, and a number of midwater fishes have been reported to prey on lanternfishes (Paxton, 1967b). According to Ahlstrom (1969), myctophids and gonostomatids fill an exceedingly important ecological role as forage fishes. They serve as a vital link between the zooplankton community and the larger predator fishes, including tunas and billfishes (Ahlstrom, 1969). These fishes, especially the myctophids, appear to occupy an important position in the trophic structure of offshore, basin waters similar to that of the northern anchovy (discussed above) in shallower, inshore waters.

v. Reproduction and Early Life History

Little information is available on the prespawning and spawning behavior of deep-sea fishes off Southern California. However, the developmental stages, and the distribution and abundance

of eggs and larvae of the more common species have been studied and are fairly well known. Much of this research has been carried out by Dr. E. H. Ahlstrom and co-workers at the Southwest Fisheries Center in LaJolla and based on CALCOFI and other surveys of eggs and larvae in the eastern Pacific.

Paxton (1967b) in a brief account of myctophid reproduction, indicated that nine of the resident lanternfishes breed in or near the San Pedro Basin. He found gravid females of *Stenobrachius leucopsarus* from October through April, of *Triphoturus mexicanus* from June through September, and of *Lampanyctus ritteri* in January, June, August, October and December indicating a year-round breeding season for the species. The three species are the most abundant lanternfishes in the basin. The occurrence of 15-17 mm postlarvae of *S. leucopsarus* and *T. mexicanus* during five months of the year supported the hypothesis of a long breeding season for these species. No young were taken of six of the least frequently captured species, and according to Paxton at least some of these species may be expatriates, unable to reproduce in the basin environment. Many species of Southern California deepwater fishes may be expatriates owing largely to the multiple origin and transitional nature of the water masses in the region (Ebeling, et al. 1970b).

Moser and Ahlstrom (1970) have described and illustrated the developmental stages, from newly hatched larvae to juveniles, of 14 species of myctophids with narrow-eyed larvae occurring in the California Current region off California and Baja California. They also provided information on distribution and relative abundance of these species. In terms of percentage contribution to total number of larvae collected

in the 1955-60 CALCOFI surveys off California and Baja California, the most abundant lanternfishes were *Triphoturus mexicanus* (36.9%) *Stenobranchius leucopsarus* (22.7%), *Diogenichthys laternatus* (12.0%) and *Lampanyctus ritteri* (4.6%). For strictly Southern California waters, Moser and Ahlstrom's summary showed that in terms of average occurrence (percentage of positive hauls) the principal myctophid larvae were *S. leucopsarus* (40.6%) *Protomyctophum crockeri* (23.9%), *L. ritteri* (23.0%), *T. mexicanus* (22.2%), and *Tarletonbeania crenularis* (15.2%). In terms of average number of larvae per station occupancy, *S. leucopsarus* was by far the most abundant lanternfish larvae in Southern California.

Ahlstrom (1965) showed that four lanternfishes, *S. leucopsarus*, *T. mexicanus*, *L. ritteri*, and *T. crenularis*, the gonostomatid, *Vinciguerrria lucetia*, and the bathylagid, *Leuroglossus stilbius*, all had parts of their larval distribution in Southern California waters. Of these species, *L. stilbius* had the highest concentration of larvae in the region. In a comprehensive study, Ahlstrom (1958) described the development, from the embryonic to the adult stage, and distribution of *V. lucetia* which is one of the most abundant deep sea fishes and an important forage species for predatory fishes.

The deep-sea pelagic fishes commonly have their eggs and larvae distributed in the upper 150 m of the water column providing along with diel vertical migration an ecological link with other adaptive zones in Southern California waters. Ahlstrom (1959) found that most fish larvae including those of deepwater species occurred in the upper mixed layer and in the upper part of the thermocline between the surface and

approximately 125 m. Lanternfish larvae were seldom taken in the upper 23 m and those of the *S. leucopsarus*, *T. mexicanus*, and *L. ritteri* occurred mostly between 24 and 64 m. Larvae of *Electrona* spp. were found to have the deepest distribution (60% below 100 m) of the lanternfish studied. Larvae of *Vinciguerrria lucetia* occurred between the surface and 122 m with the largest concentration between 24 and 48 m. Larvae of *Leuroglossus stilbius* occurred in greatest abundance within or below the thermocline, and their vertical distribution was not completely covered by hauls extending to approximately 285 m. *L. stilbius* was much more abundant in night than in day collections. Ahlstrom showed that based on a survey (Norpac) of North Pacific waters in general that about one-ninth as many larvae were taken in the 131 to 262 meter interval as in the 0 to 131 meter interval. Half of the larvae taken in the deeper level belonged to a single genus *Argyrolepecus* (Sternoptychidae).

As has already been mentioned in Section c. ii., larvae of three deep-sea pelagic families Bathylagidae, Gonostomatidae, and Myctophidae, contribute significantly (18 to 43% of all larvae captured in 1955-60 CALCOFI surveys) to the total number of fish larvae captured in the California Current region and in Southern California waters.

d. Epipelagic and Other Generally Pelagic Fishes

Table 11-11 in Horn (1974) provides a mixed list of 80 species in 30 families all of which are pelagic to a certain degree in Southern California. Because they frequently occur in more than one of the adaptive zones or habitats discussed above, no strict categorization has been made. The Southern California Bight offers

both nearshore or coastal and offshore or high seas environments and the habitat diversity is partially illustrated in this list of fishes. Some of those listed are rare such as the Zedidae, Lophotidae, Regalecidae, Trachipteridae, and Luvaridae whereas others are common such as the Engraulidae, Merlucciidae and Scomberesocidae. Certain species are truly epipelagic (in surface layers of open waters) such as the Exocoetidae, Hemirhamphidae, Belonidae, and Molidae whereas others have a wider depth range such as the Bramidae, Xiphiidae, Scombridae, Centrolophidae, and Tetragonuridae. Some species listed in the table are coastally-oriented such as the Engraulidae, Clupeidae, Caragidae, and Stromateidae, while others are more offshore or high seas fishes such as the Lamprididae, Coryphaenidae, Trichiuridae, Istiophoridae Bramidae, and Tetragonuridae. Table II-11 in (Horn, 1974) functions in providing a list of fishes known to occur only rarely or uncommonly in Southern California waters. More than 50% of the 80 species are rare and almost 75% are either rare or uncommon based on an occurrence evaluation of common, uncommon, and rare by Miller and Lea (1972).

An airborne monitoring system has recently been used (Squire, 1972) to assess the abundance of some pelagic fishes off Southern and Central California. Pacific bonito (*Sarda chiliensis*), and yellowtail (*Seriola dorsalis*), were observed in greater frequency and quantity during the day whereas the northern anchovy, jack mackerel, and Pacific mackerel (*Scomber japonicus*), were observed in greater frequency and quantity during the night. Pacific baracuda (*Sphyræna argentea*) was observed in greater quantity at night but more frequently during the day. The study showed that between 1963 and 1969 indices of apparent

abundance declined for jack mackerel, Pacific mackerel, Pacific sardine, Pacific bonito, Pacific barracuda, and yellowtail but increased slightly for the northern anchovy. The index was found to closely follow estimates of total abundance for the Pacific mackerel, a species for which reliable estimates of total abundance are available. The migrational patterns of albacore, anchovies and Pacific lake are shown on Figures II-57, II- 58, II-59.

e. Nektonic Invertebrates

Many of the larger planktonic invertebrates, particularly crustaceans, have such well developed swimming abilities that they border on being nektonic. These major groups, including the cephalopods euphausiids and decapods, are covered in Section II.E.2.

Another group of invertebrates which don't exactly fit into the neat plankton-nekton-benthos classification are those (epibenthic or demersal) which spend much of their time associated with the bottom, but part of their time, often during the night, in the water column as weakly swimming nekton. Many species fit into this category, particularly mysids and representatives of other crustacean groups. True nektonic invertebrates are less well studied and well known than are the fishes. Borderline or true nektonic invertebrates of commercial or recreation importance in California and which occur in Southern California waters are listed below (Frey, 1971).

Crustacea	
Ocean shrimp	<i>Pandalus jordani</i>
Bay shrimps	<i>Crango</i> spp.
Spot Prawn	<i>Pandalus</i> spp.
Pelagic red crabs	Galatheididae

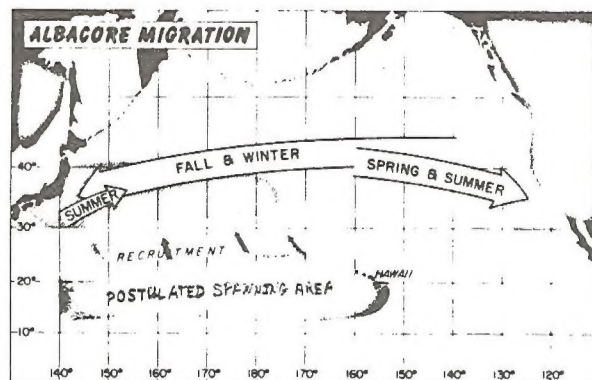


Figure II-57. Albacore migration. From: McGary, et al. (1961)

ANCHOVY TAGGING RESULTS

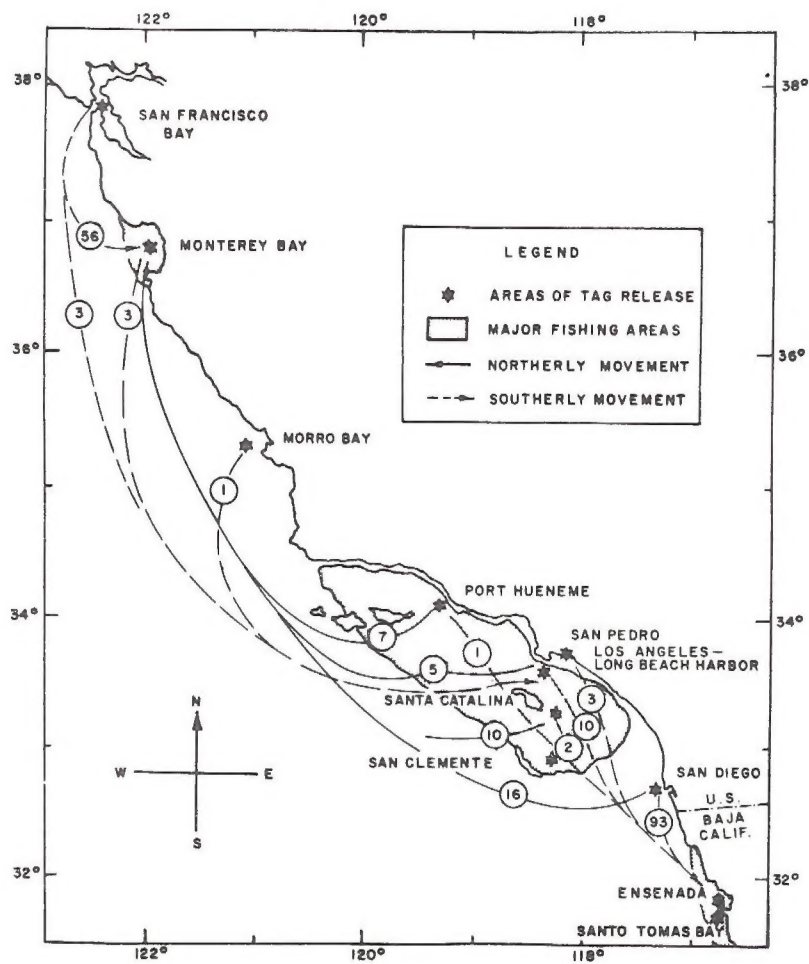


Figure II-58. Major movements of anchovies tagged and recaptured march 14, 1966 through May 31, 1969. From: Messersmith (1969).

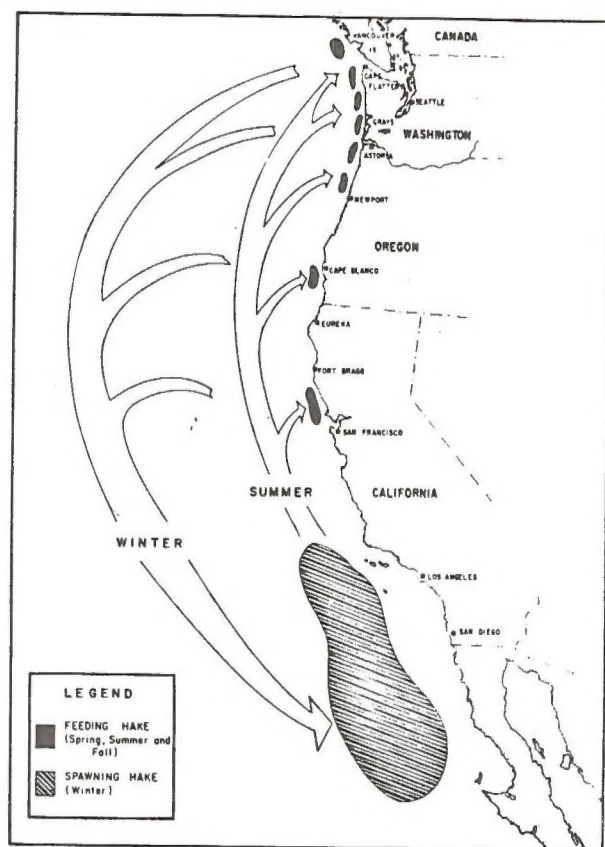


Figure II-59. Seasonal migrations and distribution of Pacific hake. From: Alverson and Larkins (1969).

Mollusca

Market squid

Loligo opalescens

The squid *Loligo opalescens* is an important commercial wetfish and is present in sufficient numbers to be important to the ecology of the pelagic zone (See Section II.G.5. for further details on this species). Most important to the pelagic ecosystem, however, are pelagic red crabs belonging to the decapod family Galatheididae. According to Frey (1971):

Pelagic red crabs occur in massive concentrations in the California Current, either as pelagic or bottom dwellers. Pelagic red crabs graze directly upon phytoplankton and eventually enter the diet of a large variety of marine life such as sea birds, whales, oceanic game fish, common kelp-bed game fishes, and bottom fish such as rockfish. Migratory gamefishes, such as yellowfin tuna, albacore, and skipjack, depend heavily upon pelagic red crabs for food during their annual journey into the California Current.

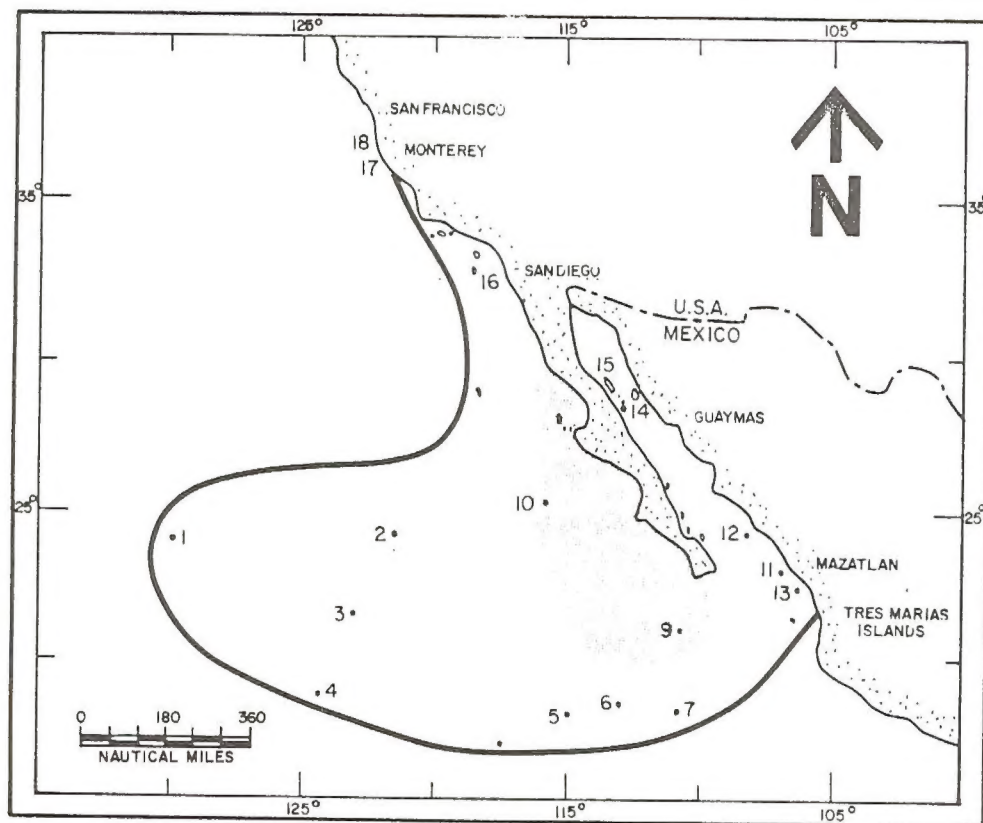
Concentrations of pelagic red crabs occur close to sites of upwelling, and their distribution is controlled by climatic variations and mass transport variations in the California Current. The Southern California and Davidson counter currents brought large quantities of these crabs north of their normal range in 1959 and 1960 and numbers were stranded on beaches along the California coast.

It has been estimated that a floating otter trawl with a 326-square-foot mouth could catch at least 2.5 tons per trawling hour. This catch could be made by fishing selectively in areas where the pelagic red crabs are "swarming." Higher catch rates to 25 tons per hour have been suggested for demersal otter trawl fishing in upwelling areas and at depths that correspond to the oxygen minimum. These catch rates have been verified by field experience in the California Current. Soviet factory trawlers took 5,00 tons in an experimental fishery off Baja California in 1967.

There is little doubt that pelagic red crabs represent a large resource. Their small size, 1 to 2 inches, and variable occurrence off California make their use in the near future very improbable. It appears that for some time to come they will remain an important forage for the multitude of pelagic and bottom fishes off Baja California.

The general distribution of the red crab is outlined in

Figure II-60.



OBSERVATION:

- | | |
|-------------------------------------|--------------------------------------|
| 1 1859 TYPE LOCATION | 10 1957 ISLAND CURRENT SURVEY CRUISE |
| 2 1960 TETHYS EXPEDITION | 11 1960 TUNA OCEANOGRAPHY 60-1 |
| 3 1960 TETHYS EXPEDITION | 12 1960 TUNA OCEANOGRAPHY 60-1 |
| 4 1960 TETHYS EXPEDITION | 13 1961 CALCOFI 6108 |
| 5 1957 TUNA SPAWNING SURVEY CRUISE | 14 1961 BEACH STRANDING |
| 6 1957 TUNA SPAWNING SURVEY CRUISE | 15 1961 BEACH STRANDING |
| 7 1957 TUNA SPAWNING SURVEY CRUISE | 16 1961 BEACH STRANDING |
| 8 1957 ISLAND CURRENT SURVEY CRUISE | 17 1961 BEACH STRANDING |
| 9 1957 ISLAND CURRENT SURVEY CRUISE | 18 1859 BEACH STRANDING |

Figure II- 60 Outlying occurrences and limits of distribution of the red crab, *Pleuroncodes planipes*. (Shaded area indicates region of greatest abundance) From: Boyd (1967, as presented in Dames and Moore, 1975)

f. Diseases and Environmental Stresses

i. Chlorinated Hydrocarbons and Trace Metals in Fishes

In an analysis of chlorinated hydrocarbons and trace metals in the tissues of fishes, SCCWRP (1973a) found the highest DDT and PCB values in muscle tissue of dover sole in specimens collected near the Whites Point, Hyperion, and Orange County outfalls (Figure II-60. These values were significantly higher than those found at Santa Catalina Island and in areas to the northwest towards Point Hueneme. SCCWRP pointed out that the Whites Point outfall system has been a significant point source of chlorinated hydrocarbons in the past and concentrations of DDT in the sediments near these outfalls reflect the magnitude of the input. PCB values showed a similar pattern.

DDT concentration in the abundant midwater myctophid, *Stenobrachius leucopsarus*, is highest in specimens collected in the Santa Monica Bay area and much lower in areas further from the bay and the site of DDT discharge (Reuben Lasker, unpublished abstract, 1973, Western Society of Naturalists Meeting, San Diego).

About 60% of the composite samples of muscle tissue from dover sole captured during 1971 and 1972 in trawls between Redondo Canyon and the Western entrance of Los Angeles harbor exceeded the maximum total DDT concentration (5 mg/wet kg) by the U. S. Food and Drug Administration in fish to be offered for sale (SCCWRP, 1973a). As mentioned in Section b.ii., dover sole was the most frequently captured species in the SCCWRP (1973a) survey.

The overall average concentrations of metals in Southern California dover sole liver tissues were within the general ranges of concentrations

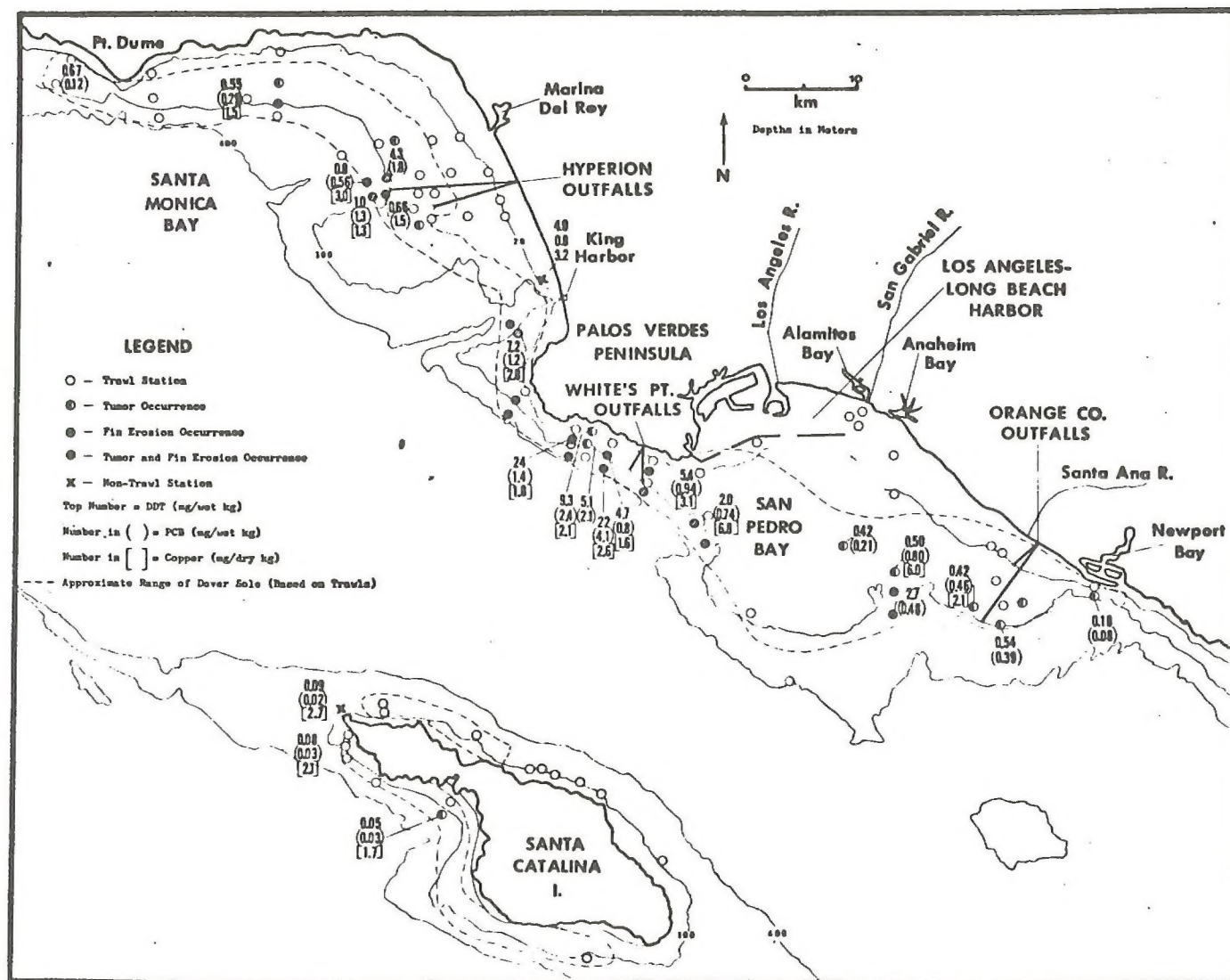


Figure II-61 Concentrations of DDT and PCB (mg/wet kg) in muscle tissue and of copper mg/dry kg) in liver tissue, and occurrence of tumors and fin erosion in dover sole collected at stations in the 1969-1972 trawling surveys by SCCWRP (1973a) in Southern California waters.

reported for other Pacific and Atlantic ocean fishes (SCCWRP, 1973a). Concentrations of selenium in albacore (*Thunnus alalunga*) liver exceeded those in dover sole livers by an order of magnitude. Concentrations of silver in dover sole livers appeared to be higher than the values reported for other fishes. Copper concentrations in liver tissue of dover sole from SCCWRP (1973a) survey stations are given in Figure II-60. The data indicates that concentrations of 12 metals in livers of dover sole (known by their DDT and PCB levels to have been associated with sediments with high metal concentrations) do not increase as a result of exposure to and feeding in the contaminated sediments.

ii. Diseases in Nearshore Demersal Fishes

SCCWRP (1973a) found tumors on one or more individuals from four flatfish species, dover sole, slender sole (*Lyopsetta exilis*), hornyhead turbot (*Pleuronichthys verticalis*) and California tonguefish (*Symphurus articanda*) and anamalous fishes were found in all of the five Southern California areas surveyed. Of the four species, dover sole was most frequently affected. The overall incidence of tumor-bearing specimens collected is given in Figure II-61.

The data suggest that the occurrence of tumors in dover sole may be a function of the early life history of this species (SCCWRP, 1973a). Environmental or genetic factors involved in tumorigenesis possibly are associated with the areas in which the fish first settle from their planktonic stages and not necessarily with the areas from which the fish are later collected. However, poor water quality may influence either tumorigenesis or the frequency of tumor-bearing fish by causing changes in competition, concentration, predation pressure, migration patterns, tumor rejection, or other factors affecting fish health. In

spite of the ubiquity of tumors in bottom flatfishes, the factors in initiating and maintaining the disease in the fish population are unknown.

Of the 121 species of fish collected during the 1969-72 SCCWRP (1973a) trawling surveys, 35 species had at least one specimen with eroded fins. The percentage of species with fin erosion was lowest in the Port Hueneme area (4%) and highest off Palos Verdes (45%). Two species, dover sole and white croaker (*Genyonemus lineatus*) were the most commonly and frequently affected species. The distribution of dover sole with fin erosion is given in Figure II-60. Both fin erosion and tumors in the dover sole appeared more frequently in small or young fish.

Stress resulting from biological accumulation of metals has been suggested as a cause of fin erosion in fishes. However, the SCCWRP (1973a) data suggest that fin erosion of the dover sole cannot be attributed to the accumulation of high concentrations of any of the studied trace constituents in vital organs. Fish from the Palos Verdes shelf, where sediments are highly contaminated and disease incidence is high, have metal concentrations no higher than those in fish taken off Santa Catalina Island. Of the trace metals in liver tissue from both affected and apparently healthy fish from the Palos Verdes area, only the zinc concentration was higher (and only slightly) in diseased fish. DDT concentrations were not significantly different, but PCB concentrations were slightly higher in diseased fish. SCCWRP (1973a) suggested further analysis of zinc, PCB, and other trace constituents in diseased and normal fish.

At least two types of fin erosion diseases occur in the Southern California species studied thus far (SCCWRP, 1973a). The first is characterized by damage to fin tissue and no degeneration of internal organs. The characteristics and localized occurrence of the disease in flatfishes, rockfishes, and other bottom dwelling species suggest that locomotor behavior and sediment contact may be important factors in the development of the disease. The second type of fin erosion is characterized by predominant involvement of the caudal fin and by bloody external lesions and occurs in active free-swimming nearshore species, primarily white croaker. The severity of tail erosion in this species may stem from continuous irritation caused by increased turbulence on the fin during swimming.

iii. Asymmetry as a Possible Measure of Environmental Stress

Valentine, Soule and Samellow (1973) have recently examined the use of fluctuation asymmetry as a possible measure of environmental stress in fishes. Fluctuating asymmetry is defined as simply the random deviation from perfect symmetry of any bilateral anatomical character. Using asymmetry analysis on three species - barred sand bass (*Paralabrax nebulifer*), grunion (*Leuresthes tenuis*), and barred surfperch (*Amphistichus argenteus*)--from Southern California and Baja, California, Valentine and co-workers were able to define two possible asymmetry trends, historical and geographic. They found asymmetry values to increase toward highly populated areas (Southern California) both from the north and south and also with time within Southern California. The increase in asymmetry correlated well with the known distribution of var-

ious pollutants - the last was tentatively concluded to be the likeliest explanation. However, as SCCWRP (1973) has stated, the causative factors cannot yet be identified because of the general lack of knowledge of the behavior of environmental contaminants in fishes and in the environment and because of the limited knowledge of the natural and man-made factors regulating the biology of coastal fish populations.

iv. Effects of Wastewater Discharge

Between August 1969 and May 1972, SCCWRP (1973a) made quarterly trawls off Orange County in the vicinity of the two municipal wastewater outfalls of the county sanitation districts. At the beginning of the study period, wastewaters were being discharged through a nearshore outfall. On 1 April 1971, use of this outfall was terminated, and discharge through a deeper outfall farther offshore was initiated. Catch data for white croaker and dover sole were generally inconclusive as to possible effects on occurrence and abundance of these two species. White croaker catches did decrease at the old outfall but due to variability in the data it could not be determined whether the decline in abundance began before or after the discharge was terminated. There were also changes in abundance and size composition of the dover sole catch at stations closest to the new outfall. Following initiation of the new discharge, the abundance and size of dover sole appeared to increase, particularly at the station downstream from the outfall. SCCWRP (1973a) concluded that observations of white croaker and dover sole indicate that both natural and wastewater - related changes in environmental conditions cause changes in the abundance and size composition of fish populations that can be detected and distinguished with

present gear at sampling intervals as great as every three months.

v. Effects of Kelp Harvesting and Fluctuating Size of Kelp Beds

Three investigators, Limbaugh (1955), Quast (1968e) and Davies (1968), all arrived at the same conclusion, namely that, within the limits of the methods used for study, no evidence has been obtained that kelp harvesting has a measurable effect on the associated fish populations. Their conclusions applied only to what may be considered routine or normal harvesting practice, in which not over one-half of the kelp plant (linear dimensions) is taken by the harvester and no single bed is harvested more than three times a year. The following observations and measurements by Quast (1968) helped him arrive at the above conclusion. There are high concentrations of fish larvae in the kelp canopy but probably only a minimal number taken aboard a kelp-cutter. Fishes are not driven away by kelpcutters and only a small amount (11% calculated) of the invertebrate material attached to kelp is brought on board the cutter, thus having little effect on the available fish food. Kelp was found in quantity in the digestive tract of only three species of fishes associated with kelp - opaleye (*Girella nigricans*), halfmoon (*Medialuna californiensis*), and senorita (*Oxjulis californica*). Even these three species may ingest the algae for the animal material on its surface. Tall plants encourage bottom fishes to rise out of visual range of the ocean floor which leads to utilization of food resources present in the entire water column. Removal of the canopy opens the bed and more forage fishes probably become visible and available to predators below. Opening up the bed possibly encourages

invasion by important bait fishes (e.g. anchovies and jack mackerel).

Fish populations have apparently been affected by periodic large scale declines of kelp beds in Southern California. According to Stephens (1973), the rocky shore area has undergone a radical environmental change since 1956-59 when the kelp beds disappeared, greatly modifying ecological relationships and species composition of fishes in the area. He believes that these fishes are reaching a new equilibrium based on observations off Palos Verdes where fish density has been drastically altered but with most species occasionally present. Stephens indicates that apparently some "kelp-bed species" now survive primarily in artificial habitats such as King Harbor (discussed in Section b. viii.) and that such areas may serve as refuges for ecologically displaced species.

vi. Effects of Commercial and Sport Fishing

Catches of both sport and commercial fishes have fluctuated greatly in Southern California in the past 25 or so years (SCCWRP, 1973a). Almost all of the sport and commercial fishes landed in Southern California are either pelagic fishes, taken by a variety of methods, or inshore predatory fishes such as halibut and rockfishes, caught by selective hook-and-line fishing. With the exception of a few areas, such as Santa Barbara, bottom fishes caught by commercial trawling represent an insignificant fraction of the total catch, a direct contrast to the effort distribution in central and northern California where trawling and long-line fishing of bottom fish communities accounts for much of the fish landed. These differences in fishing modes should result in major differences in the abundance,

health, and diversity of the bottom and nearshore fish communities of the two areas (SCCWRP, 1973a). Within the Southern California Bight, distribution and selectivity of fishing effort differs between coastal and offshore areas. Commercial trawling within the Bight has been restricted primarily to the shelf areas of the Santa Barbara Basin with little or no trawling of bottom fishes to the south. In contrast, sport hook-and-line fishing for the larger, more pelagic and predatory fishes has been intense along the coasts of Los Angeles, Orange and San Diego Counties, and off Santa Catalina and, more recently, Santa Cruz Islands. These variations must be recognized as factors affecting the health, abundance, and ecological stability of fish populations (SCCWRP, 1973a).

Stephens (1972) in a review of the status of bay and inshore fishes concluded that the coastal marine fish fauna of Southern California has undergone considerable change in the last 30 years. Sardines, Pacific mackerel, giant sea bass and many other economically important sport and commercial species that are residents of the coast have almost disappeared. Important fish stocks now consist largely of seasonal migrants, the tunas. The value of tunas generally exceeds the value of all other fisheries combined. Using data from Frey (1971), Stephens showed that the wetfish industry is one-sixth as productive now as in 1936 while the California catch of tunas is half as productive on the basis of catch per unit effort data. According to Stephens, changes in commercial and sport species can be largely attributed to fishing pressure although habitat destruction and pollution have had their effects.

5. Marine and Shore Birds

A variety of terrestrial and marine birds are associated with the Southern California Bight and coastal area. The California State Fish & Game Department has recently published a synopsis of California Coastal Fish & Wildlife resources (California Fish & Game, 1973) which is included in the following text as the most up to date information on avian coastal habitat and resources in Southern California.

Santa Barbara County

Coastal areas of importance to bird activity.

Uplands

Sand dune areas comprise the only unique upland habitat on the coastal zone. The dunes south of the Santa Monica River and fronting Vandenberg Air Force Base provide excellent habitat for quail where exceptional high populations are found. A small colony of least terns use uplands adjacent to the Santa Ynez River as a nesting site.

Wet lands

Goleta Slough
El Estero (Carpinteria Marsh)
Santa Ynez River
Goleta Point Marsh
Santa Maria River
Devereaux River

The above habitats offer approximately 170 acres for the existence of some 150 species of water associated birds, plus providing life requirements to thousands of migrating and resident birds in the Pacific Flyway.

Significant numbers of shorebirds, waterfowl and a variety of other water associated birds are dependent on Santa Barbara coastal wetlands for survival. The County possesses a scant 900 acres of such wetlands, 80 percent of which are located at Goleta Slough and Carpinteria Marsh and on the Santa Ynez River. The Department of Fish and Game, in August 1970, published a report on "The Natural Resources of Goleta Slough." The slough is used by 51 species of water associated birds. The Department estimated that the slough supports 400,000 bird days of use annually.

Carpinteria Marsh, a 200-acre wetland, provides an estimated 170,000 bird day's use annually. Bi-weekly counts in 1966-1967 showed that the marsh was used by 44,000 ducks. Wildlife use of the Santa Ynez and Santa Maria Rivers taken on an acre-for-acre basis is comparable to that of Carpinteria Marsh.

Sandy Beach

A total of 83.5 miles (76 percent) of Santa Barbara County's shoreline is classed as sandy beach. About 67 percent of Santa Barbara's sandy beach is privately owned, but most remains undeveloped. The 14 miles of federally owned sandy beach is mostly within the boundary of Vandenberg AFB. Low human use of these beaches is conducive to undisturbed use by the dependent bird species. Some shorebirds that are supported by this habitat type for feeding and nesting include the long-billed curlew, semi-palmated plover, American golden plover, black-billed plover, whimbrel, sanderling, western sandpiper and the least sandpiper.

The 9.5 miles of state and county owned beaches receive nearly 750,000 visitors annually. Such heavy use precludes nesting activities on the beach; however, during the off-season for bathers and during early morning and late evening hours of the summer the beaches are utilized by shorebirds.

Rocky Shoreline

About 26 miles (24 percent) of the Santa Barbara County Coast is classified as rocky beach and rocky headlands. The precipitous cliffs and rocky shore provide nesting and feeding habitat for the black oyster catcher, black turnstone, ruddy turnstone, spotted sandpiper, surfbird, and western gull.

Offshore Rocks

Lion Rock and rocks at Pt. Arguello have been classed as non-breeding-roosting sites and as such are of less importance to seabirds than the nesting rocks of central and northern California (see Figures 2 of appendix).

Birdwatching, photography and scientific study comprise the majority of non-appropriative wildlife use of Santa Barbara's coastal wetlands and uplands. Of the wetland areas, Goleta Slough receives the most use of this type. About 250 members of the Audubon Society use Goleta Slough throughout the year for bird observation. The area is included in the Society's annual and nationwide bird count. Schools within reasonable travel distance use Goleta Slough as an outdoor classroom. It is estimated that 1,100 students from the University of California at Santa Barbara utilize the slough for various studies in the life science field.

Carpinteria Marsh also receives heavy use from students at the University of California. An agreement between the University and the property owners allows a portion of the marsh to be used for study that is otherwise closed to the public.

Ventura County

Uplands

Most of the upland habitat types found in Ventura County's coastal zone also occur in inland areas of the county and none are singularly significant in the maintenance of the county's upland and big game species. Without the necessary habitat, however, those upland animals and birds now found in the coastal zone would disappear.

Wetlands

Santa Clara River
McGrath Lake
Mugu Lagoon
Ventura River

Shorebirds, waterfowl and a number of other water-associated birds are dependent on the county's coastal wetlands for survival. Some, 2,290 acres of marsh and mudflat habitats are found at Mugu Lagoon, Santa Clara River, Ventura River, and McGrath Lake. Mugu Lagoon itself contains 95 percent of the county's wetlands. It is estimated that in excess of 120 species utilize the marsh and mudflats of Mugu Lagoon and other wetlands of the county. The light-footed clapper rail, a species now in danger of extinction, is found at Mugu Lagoon, one of the few remaining areas in California supporting clapper rails. The degree of bird use on Ventura County's wetlands has not been documented. However, it is estimated that such use is comparable, acre for acre, to that occurring in the wetland areas of neighboring counties. The 360 acre Goleta Slough in Santa Barbara County, for instance, receives in excess of 400,000 bird day's use and/or 1,100 bird days of use per acre.

Sandy Beach

About 38 miles (93 percent) of the Ventura County shoreline is classed as sandy beach. Of this amount, 28 miles (74 percent) is in public ownership. For the season of 1968-1969 the Department of Parks and Recreation estimated that its beaches in Ventura County accommodated over one million visitors. This use occurs primarily during the summer months which would preclude successful nesting success by species utilizing sandy beaches for this activity. However, during the winter migration of shorebirds and water fowl, the beaches provide feeding areas for long-billed curlew, semi-palmated plover, American golden plover, black billed plover, whimbrel, sanderling, western sandpiper, and the least sandpiper. Any future county plans for beach utilization should include data for the requirements of nesting species for this habitat.

Rocky Shorelines

A little over three miles of the Ventura shoreline is classed as rocky beach. The precipitous cliffs and rocky shore provide nesting and feeding habitat for the black oystercatcher, black turnstone, ruddy turnstone, spotted sandpiper, surfbird and western gull. About half of this habitat type remains in public ownership.

Offshore Rocks

Bass Rock and rocks of Point Mugu have been classified as non-breeding roosting sites and as such they are of minor importance to sea birds.

The Ventura County coastal zone does not contribute significantly to the appropriative use of upland game and big game species, except that most of the common snipe bagged in Ventura County were taken in the zone. Most of the 35,400 ducks and 500 geese taken in the 1969-1970 season were also taken in the coastal zone.

Los Angeles County

Uplands

Most of the upland habitats of the Los Angeles County coastal zone have been developed. The remaining upland habitats of the zone do not significantly contribute to the maintenance of upland game and big game species in the county.

Wetlands

Bixby Slough
Ballona Creek
Colorado Lagoon

Shorebirds, waterfowl, and a number of the other water-associated birds are dependent on the county's coastal wetlands for survival. The county possesses some 270 acres of tidal marsh and freshwater marsh, remnants of once large wetland marshes and mudflats. About 96 percent of Los Angeles County's marshes and mudflats have been lost to dredging, filling, and other developments, destroying the value of these habitats for wildlife. The primary value of the remaining acreage of marsh is providing wildlife an oasis of natural habitat in the midst of a metropolis.

Sandy Beach

About 51 miles (77 percent) of the county's shoreline is classed as sandy beach. Sandy beach habitat provides feeding and nesting areas for many birds including the long-billed curlew, semipalmated plover, American golden plover, black-bellied plover, whimbrel, sanderling, western sandpiper and the least sandpiper. During the summer months heavy human use of the beaches has substantially reduced the value of this habitat for those species using the area for feeding and has precluded nesting. However, during the offseason for bathers, the beaches are utilized by migrating shorebirds as feeding sites.

Rocky Shoreline

About 26 miles (24 percent) of the Los Angeles County coast is classed as rocky beach and rocky headlands. The precipitous cliffs and rocky shores provide nesting and feeding habitat for the black oystercatcher, black turnstone, ruddy turnstone, spotted sandpiper, surfbird, and dunlin. About half of this habitat type remains in public ownership.

Offshore Rocks

Flat Rock Point and Portuguese Point have been classed as non-breeding-roosting sites.

The Los Angeles County coastal zone does not contribute significantly to the appropriate use of upland or big game species or waterfowl. Birds and other wild creatures make a significant contribution to the outdoor experience of persons residing in or visiting the coastal zone, even though a specific conscious effort may not have been made to view them. The raucous call of a gull or the familiar cry of the killdeer are inherent parts of the coast. It is therefore considered that the user days attributed to outdoor recreation of the coastal zone can also be applied to nonappropriate use of the wildlife resources.

Orange County

Uplands

Most of the natural upland habitats of the Orange County coastal zone have been destroyed by land development. The remaining upland habitats of the zone provide no significant support for upland and big game species.

Wetlands

Anaheim Bay

Bolsa Bay

Newport Bay

Upper Newport Bay

Significant numbers of shorebirds, waterfowl and other water-associated birds are dependent on Orange County's coastal wetlands for survival. The county possesses about 2,200 acres of such wetlands located at Anaheim Bay, Newport Bay, Bolsa Bay, Sunset Bay and Irvine Marsh. The Department has identified over 100 species of birds utilizing Anaheim Bay, including 23 known resident species. Breeding colonies of light-footed clapper rails occur at Anaheim Bay and Upper Newport Bay. The light-footed clapper rail, a species that has been identified as being in danger of extinction, is totally dependent upon the remaining salt marshes of South-

ern California. Nearly 90 percent of the coastal marshes of Orange and Los Angeles Counties are already lost as wildlife habitats. The least tern, another endangered species, nests near Anaheim Bay and utilizes the marsh as a feeding area. A small colony of terns also continues to nest on the Huntington Beach State Park adjacent to the Santa Ana River. The department of Fish and Game has estimated that the Anaheim-Bolsa-Sunset Bay Complex annually supports 720,000 migratory waterfowl use days, 126,000 resident waterfowl use days and 540,000 migratory species (other than waterfowl) use days. At upper Newport Bay, the Department has classified 159 bird species. It is estimated that the Upper Bay supports 4-million bird day's use annually by shorebirds and waterfowl. Shorebird use accounts for 74 percent of this total.

Sandy Beach

About 38 miles (92 percent) of the Orange County shoreline is classed as sandy beach. Some birds supported by this habitat type for feeding and nesting activities include the long-billed curlew, semi-palmated plover, American golden plover, black bellied plover, whimbrel, sanderling western sandpiper and least sandpiper. Nearly 23 miles (60 percent) of the beach is in public ownership. High density human use of this habitat type during the summer months virtually precludes use by bird species, at least during the daytime. Birds are commonly seen along the beaches in early morning and late evening. However, during the winter, the beaches are available as feeding areas to migrating shorebirds.

Rocky Shoreline

About three miles (a percent) of Orange County coast is classed as rocky headlands (Parks and Recreation 1970). The precipitous cliffs and rocky shore provide nesting and feeding habitat for the black oystercatcher, black turnstone, ruddy turnstone, spotted

sandpiper, surfbird and western gull. About half of this habitat type remains in public ownership.

The 1969-1970 waterfowl harvest of 12,400 ducks occurred almost entirely within the coastal zone. The Irvine Marsh, the site of a duck hunting club, provided a major portion of the take.

Numerous field trips to view the bird life of Upper Newport Bay are sponsored by local conservation groups. These field trips have attracted thousands of people concerned with proposed plans to destroy wildlife habitats of the Upper Bay. Individuals, rather than groups, account for the majority use of Orange County's coastal wildlife. Birds and other creatures of the coast are viewed each day by virtually millions of people who accept them as part of the natural scene. The sighting of birds and other wildlife is an inseparable part of the pleasure people derive from their outdoor experiences. For many, wildlife may trigger no more than an unconscious awareness of aesthetic beauty and as such contribute to the meaning of life.

San Diego County

Uplands

The upland habitats of the coastal zone are also found in great abundance inland of the zone and as such are not essential for the maintenance of the upland and big game species in the County.

Wetlands

Important Bays, Lagoons, Marshes, and Streams in Coastal Zone

Tijuna River	Batiquitos Lagoon
San Diego Bay	Aqua Hediona Lagoon
San Diego River	Buena Vista Lagoon
Mission Bay	Santa Margarita River
Los Penasquitos Lagoon	San Luis Rey River
San Dieguito Lagoon	Los Flores Creek
San Elijo Lagoon	San Mateo Creek

Shorebirds, waterfowl, and a number of the other water-associated birds are dependent on coastal wetlands for survival. Indentations of the coastline at 14 locations mark the entrance to the sea for bays, lagoons, and other estuarine habitats, including some 18,000 acres of marsh, mudflat, and sheltered waters. Since 1965 the focus of interest in the coastal zone has prompted the Department to document the species and numbers of wildlife utilizing coastal wetlands. While such census data are yet far from complete, the data show heavy utilization by waterfowl, shorebirds, and a number of other water-associated birds. In 1969 shorebird surveys were initiated by the Department of Fish and Game at five locations in San Diego County. The counts taken during these surveys show the estimated days of use by shorebirds as follows:

San Elijo Lagoon	325,000
Batiquitos Lagoon	130,000
San Diego River Flood Control Channel	400,000

Waterfowl use was not estimated but would conservatively add approximately 50 percent to the above figures. The estimated use of Buena Vista Lagoon by all species is 500,000, with about 65 percent of this use attributed to waterfowl.

Three heron and egret rookeries are located in the coastal zone, two at Point Loma, and one north of Oceanside in the San Luis Rey riverbed. The rookery at the Fort Rosecrans Military Reservation supported 10 nesting pairs of great blue herons in 1969. The other sides, in addition to nesting, provide congregating locations for nearby feeding areas.

The salt pond levees in South San Diego Bay are the only areas in California and the United States where the elegant terns nest. A report regarding this activity was completed in 1968. It is estimated that the levee system supports nearly 100 nesting pairs of elegant terns. South San Diego Bay is estimated to support over three million shorebird days of use each year. Waterfowl and other water-associated birds have not been censused, but it is estimated that their use of the bay would conservatively add another 50 percent to the shorebird total. Counts in the south bay varied from a low of about 400 in May to a high of about 14,000 in June. Banding and marking studies in San Diego Bay show that birds use the San Diego Bay area as traditional wintering grounds. A report documenting the natural resources of San Diego Bay was prepared for the Department of Fish and Game in 1972.

The California black rail, Laterallus jamaicensis cotuniculus, a species classified as "rare", inhabits the coastal marshlands of the county.

Waterfowl abundance in the coastal zone of San Diego County is now relatively low, mainly due to the decline of quality habitat over the years. However, the remaining wetlands continue to provide resting and feeding areas for migratory waterfowl. Mission Bay, prior to alteration, was a historic wintering area for black brant. The San Diego River flood control channel adjacent to Mission Bay continues to provide a good growth of eelgrass in the area and is heavily used by brant. As many as 200 have been seen feeding in the channel at one time.

Sandy Beach

About 65 miles (85 percent) of the San Diego County shoreline is classed as sandy beach. Some of the birds that are supported by this habitat type for feeding and nesting include blackbellied plover, western willet, western sandpiper, whimbrel, marbled godwit, snowy plover and least sandpiper. Over half or 41 miles of the beaches are in public ownership. Public use of the beaches in the summer has altered the nesting habits of the least tern, an endangered species. To nest undisturbed, this species has moved to less desirable inland portions of the ocean front, usually in the close proximity to wetland areas. Nesting sites are located at Tijuana River, South San Diego Bay, Mission Bay, Los Penasquitos Lagoon, Batiquitos Lagoon, Buena Vista Lagoon, and at the Santa Margarita River.

It is estimated that 471 pairs of the least tern now nest in 12 colonies within the county, and of this number 75+ pairs nest

near the Santa Margarita River on Camp Pendleton.

Federal ownership of other stretches of beach, with corresponding low level use, has provided nesting area for not only the least tern, but other resident species. It is recommended that human use of federally owned beaches continue on the present limited basis.

Rocky Shoreline

About 11 miles (15 percent) of the county's shoreline is classed as rocky headlands. The precipitous cliffs and rocky shore provide nesting and feeding habitat for the black oystercatcher, black turnstone, ruddy turnstone, spotted sandpiper, surtbird, and western gull. About half of this habitat type remains in public ownership.

Offshore Rocks

Bird Rock and a rocky site at Point Loma Lighthouse are designated as nonbreeding roosting sites, and as such are of less importance to sea birds than nesting rocks along the central and northern California Coast. The San Diego County Coastal Zone does not contribute significantly to the use of upland game and big game species. It is estimated that only 10 percent of 35,800 ducks harvested in the county were taken in the coastal zone.

The Channel Islands

Three large offshore islands (Santa Rosa, San Miguel, and Santa Cruz), are situated within Santa Barbara County waters and provide important breeding and resting areas for seabirds. While these islands are important rookeries, detailed counts of nesting pairs have not been completed. The different species utilizing each island have been determined, however, and are:

<u>Island</u>	<u>Breeding Species</u>
Santa Cruz	Western gull, double-crested cormorant, Brandt's cormorant, pigeon guillemot, pelagic cormorant, black oystercatcher.
Santa Rosa	Western gull, black oyster catcher, pigeon guillemot.
San Miguel	Western gull, double-crested cormorant, Brandt's cormorant, pelagic cormorant, black oystercatcher, pigeon guillemot.

Two offshore islands, Anacapa and San Nicolas, provide major breeding sites but the number of nesting pairs of each species accommodated has not been determined. The species of birds nesting on each of these islands are:

<u>Island</u>	<u>Species</u>
Anacapa	Western gull, double crested cormorant, Brandt's cormorant, pelagic cormorant, black oystercatcher, brown pelican.
San Nicolas	Western gull, Brandt's cormorant, snowy plover.

In 1970, West Anacapa Island was the site of the only brown

pelican rookery off the California coast. There were about 550 nesting attempts in two colonies on the island, but only one known young was produced. Reproductive failure was attributed to thin eggshells, which collapsed during incubation. Double-crested cormorants nesting on Anacapa in 1970 suffered the same fate as the pelicans, with three young being produced from at least 50 nesting attempts. In 1972, another study of pelican colonies revealed that 26 young were produced from 150 nests on West Anacapa, and 31 nestlings were found in 112 nests on an island off Santa Cruz Island. Although this is an apparent increase in nesting success over 1970, substantial nesting failure was still evident. Many nests containing addled, broken, and thinshelled eggs were found.

Santa Barbara Island, Santa Catalina Island, and San Clemente Island are located off the Los Angeles County coast, and provide suitable breeding sites for a variety of seabirds. The number of breeding pairs has not been assessed but the various species utilizing each island has been determined. They are:

<u>Island</u>	<u>Species</u>
Santa Barbara	Western gull, double-crested cormorant Brandt's cormorant, pelagic cormorant, black oystercatcher, pigeon guillemot.
Santa Catalina	Western gull, double-crested cormorant, Brandt's cormorant.
San Clemente	Western gull, Brandt's cormorant, pelagic cormorant.

MAJOR ROOKERIES WITHIN THE SOUTHERN CALIFORNIA AREA
(OSBORNE & REYNOLDS 1971)

<u>Site</u>	<u>County</u>
Santa Cruz Island	Santa Barbara
Santa Rosa Island	Santa Barbara
San Miguel Island	Santa Barbara
Anacapa Island	Ventura
San Nicolas Island	Ventura
Santa Barbara Island	Los Angeles
Santa Catalina Island	Los Angeles
San Clemente Island	Los Angeles

ROOSTING SITES WITH NO BREEDING BIRDS
WITHIN THE SOUTHERN CALIFORNIA BIGHT
(OSBORNE & REYNOLDS 1971)

(See Figure II-63)

<u>Site</u>	<u>Code</u>	<u>County</u>
Lion Rock (Pt. Sal) North of Pt. Conception		Santa Barbara
Point Arguello North of Pt. Conception		Santa Barbara
Point Mugu	R-38	Ventura
Bass Rock	R-39	Ventura
Flat Rock Point	R-40	Los Angeles
Portuguese Point	R-41	Los Angeles
Reef Point	R-42	Orange
Goff Island	R-43	Orange
San Juan Rocks	R-44	Orange
Bird Rock	R-45	San Diego
Point Loma Lighthouse	R-46	San Diego

Other recent studies on the avifauna of the Southern California Bight include papers by Dillingham Corporation (1971), Gress (1970), California Department of Fish & Game (1969), Hunt (1974), Johnson (1972), Osborne and Reynolds (1971), Jehl (1973), and Bender et al. (1974). Several of these studies contain avian species lists for the Bight area.

During the 1969 Santa Barbara oil spill the California Department of Fish and Game (1969), conducted a bird census of the oil affected and unaffected areas of the Santa Barbara Channel. This report was summarized by Straughan (1971):

Aerial surveys between February 5 and March 31, 1969 recorded a total of 51 species (see Table E 5-1 of Appendix 10, Section II,E.5.) Aerial surveys between February 5 and March 31, 1969, indicated that bird numbers on the affected area remained relatively stable. Avian population for the 1,075 square miles sampled by the aerial transects was estimated to be 12,000 birds. Species groupings in order of their abundance were gulls, shorebirds, waterfowl, loons, grebes, cormorants, pelicans, and other water birds. Similar surveys conducted from April 1, to May 31, 1969 recorded a bird population of about 85,000.

These fluctuations in population levels are to be expected as the birds migrate along this portion of the Pacific Flyway. Peak numbers of birds are expected in the fall and winter. Some species such as the brown pelican and double-crested cormorants are found year-round in the area, while others such as the migratory black brandt, ashy petrel, sooty shearwater, and canvasback duck are found seasonally. The number of birds, by species groups, from the beach and aerial surveys is shown in Table E 5-2 (Appendix 10, II.E.5.).

Bender et al, (1974) in a report on the marine and shorebirds of Southern California has compiled a species list for the Bight area. This list has been divided into several overlapping categories as shown on

table E 5-3 (Appendix 10,II.E.5.). The number of species associated with with the principal habitats are as follows:

Pelagic	33 species
Littoral	55 species
Bays	46 species
Rocky Shore-Sea Cliff	27 species
Sandy Beach	35 species
Channel Islands	118 species
endemic forms (Channel Islands)	18 subspecies

These tables include 4 endangered species: the brown pelican with its breeding habitat restricted to Anacapa Island; the peregrine falcon, formerly a resident on the coastline and Channel Islands; the California least tern; and light-footed clapper rail, plus the endemic species & subspecies. These endangered species are discussed in more detail in the Threatened Species Section 11.F.6.

Perhaps the most conspicuous and numerous avian group found in the proposed OCS lease areas is the pelagic (open ocean) seabirds. This group consists of such species as shearwaters, petrels, murrelets, auklets and gulls (See Table E 5-3 Appendix 10) Section II.E.5. Some of these birds spend most of their lives on or above the open ocean habitat, coming ashore only in selected spots to breed and nest (See Figure II-63).

Such census and distribution data as exist are fragmentary with significant variations in locations, seasons, and methods of collection so that use for scientific comparison is virtually prohibited. The habitats, ranges, feeding areas and migration routes of these birds are also poorly known and require coordinated baseline research to fill in these existing data gaps.

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Near Long Beach, adjacent to Anaheim Bay Bolsa Chica Dillingham Corp. (1971) conducted a bird census which included land-birds as well as marine birds.

Five censuses of Bolsa Chica's avifauna, conducted between 23, June, and 10 October 1970, yielded a total of 15,557 birds belonging to 78 different species (Table E 5-9 Appendix 10, E.b).

The species represented can be divided between two broad ecological categories--water birds and land birds.

On the average, the species of water birds outnumber species of land birds by a factor of 3:2. In numbers of individuals, water birds outnumber land birds by a factor of 4:1 (Figure II-62).

Among the water birds, 13 species were represented by over 100 in-

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Among the water birds, 13 species were represented by over 100 individuals during at least one census. Only three species of land birds were similarly represented (Table E 5-10, Appendix 10, II.E.5.).

During the first five months of the survey period, a major portion of Bolsa Chica's avifauna consisted of migrant species. Their populations followed a pattern typical for coastal California, low summer populations, followed by a late summer upswing, and the counts leveling off into the fall.

Among the shore birds, small (e.g., sandpiper) to medium-size (e.g., Black-bellied plover) species, made up the major portion of the populations. Several tentative comparisons can be drawn between the water bird populations of Bolsa Chica and other areas:

- A. A brief survey of upper Newport Bay (31 October 1970) and counts for that area reported by the California Department of Fish and Game (Resources Agency, March 1970) support the impression that Newport Bay supports a larger number of individuals and species than does Bolsa Chica.

- B. Further, our impression from superficial surveys of the Anaheim Bay area (U. S. Naval Weapons Station) suggests that it also is numerically superior in water birds when compared with Bolsa Chica.

The brown pelican, because of its endangered status, and the double-crested cormorant, because of ominous signs regarding its future well being, are notable species of the Southern California coast. The American Ornithologists' Union (1957) check-list described the range of the brown pelican on the west coast of the United States as birds breeding on Anacapa Island (Fig. II-63), irregularly on Santa Barbara Island, on Bird Island, near Point Lobos, Monterey County and on Santa Cruz and San Miguel Islands, Los Caronades Islands and wandering as far north as southern British Columbia. According to Gress (1970) of 552 nesting attempts by brown pelicans in two colonies on Anacapa Island in 1970, only one young was produced. Double-crested cormorants fared the same fate with only one nest of three young being produced out of more than 50 nesting attempts. Failure was attributed to pesticides causing the birds to lay thin-shelled eggs. Embryos were killed when the egg was crushed beneath the normally compatible weight of the nesting bird.

Migratory birds, as classified under the conditions of bilateral treaties with Canada, Mexico and Japan (pending), are protected under provisions of the Migratory Bird Treaty Act. Other birds are additionally protected by the Bald Eagle Act of 1940, the Endangered Species Conservation Act of 1969, and the Endangered Species Act of 1973.

The U. S. Fish and Wildlife Service, U. S. Department of the Interior, is responsible for enforcing these acts, establishing and main-

taining a system of refuges, and implementing management programs. The California Department of Fish and Game protects terrestrial and coastal species within California as outlined by state law. A discussion of impacts on bird life may be found in Section III.D.3.

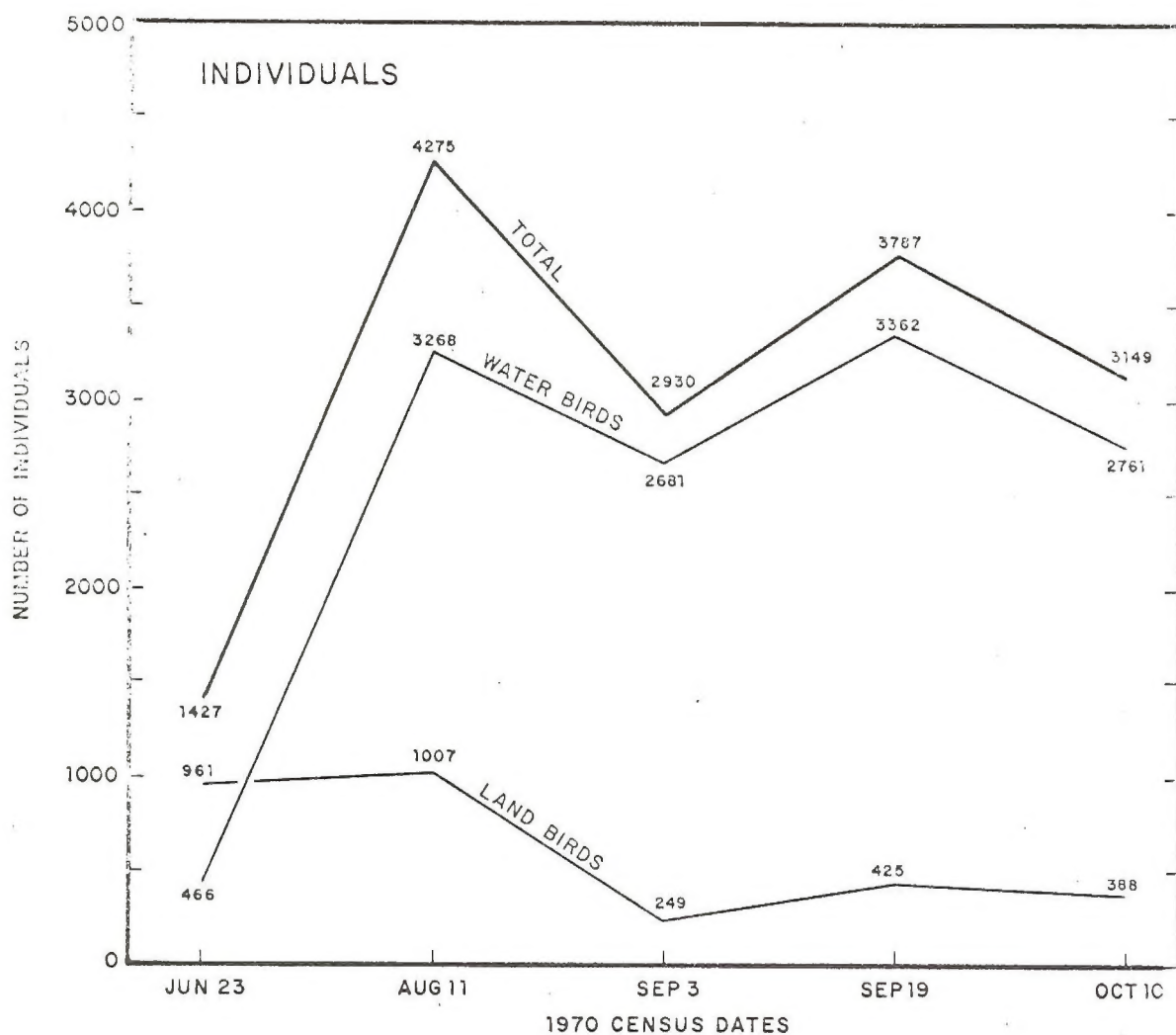
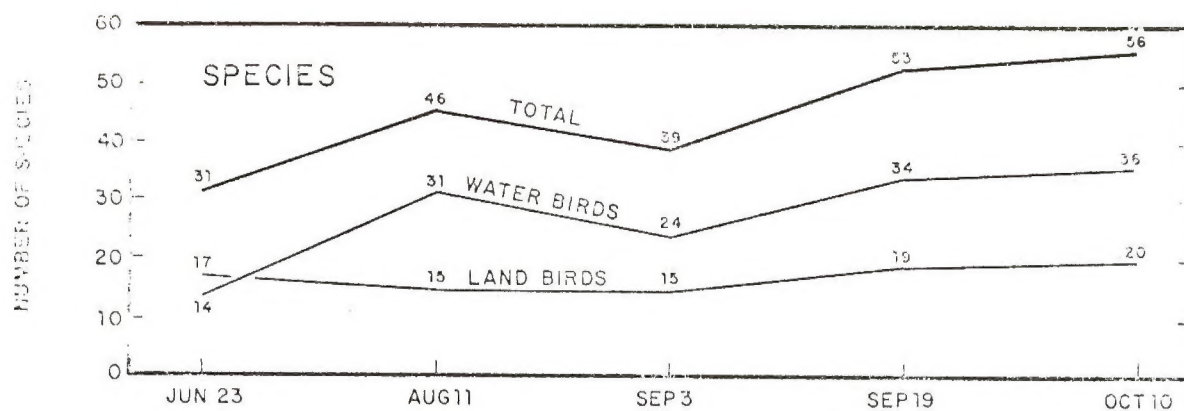


Figure II-62 From: Dillingham Corp. (1971).
Bolsa Chica census totals.

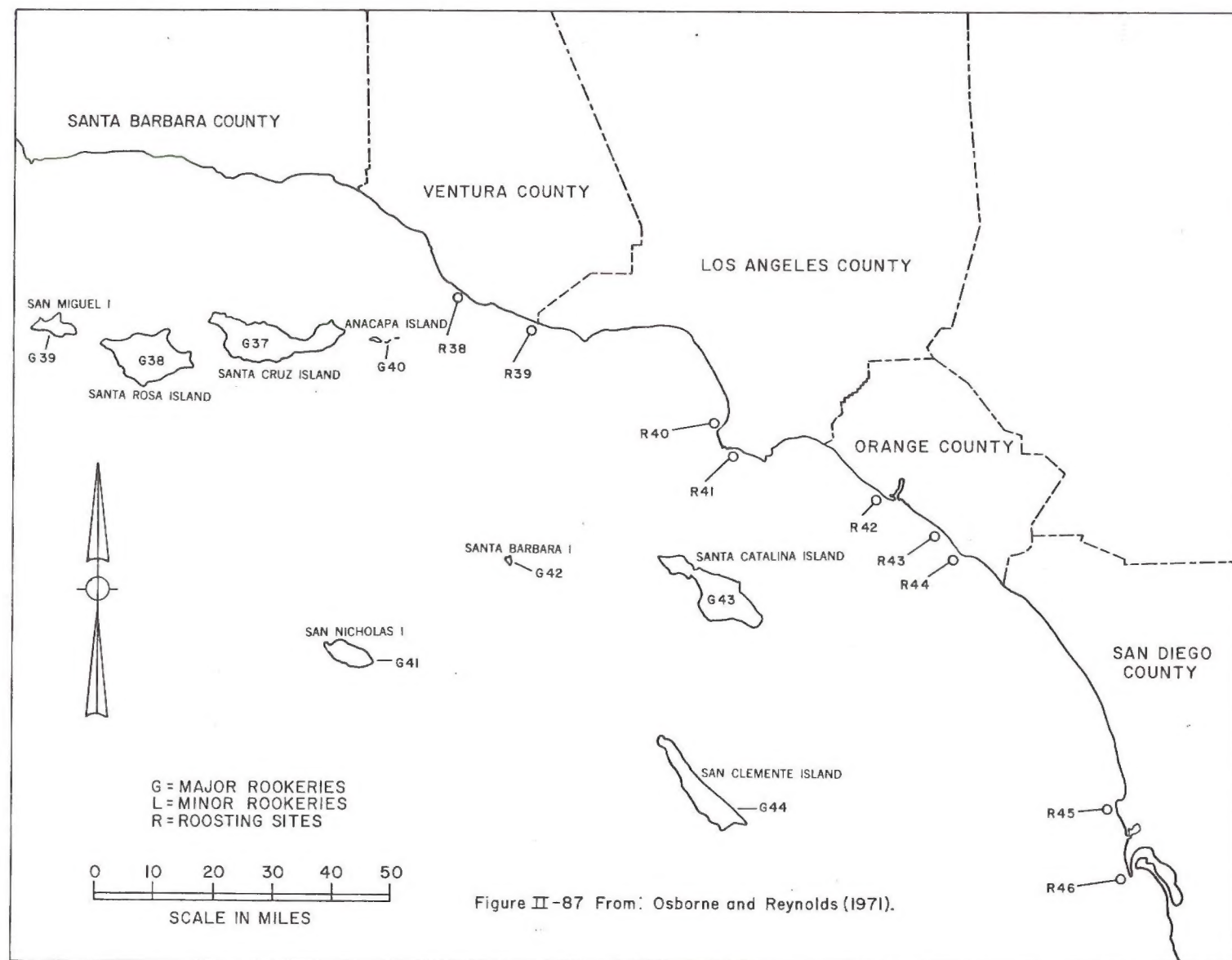


Figure II-87 From: Osborne and Reynolds (1971).

The delicately balanced marshland ecosystems are subject to impacts resulting from sporadic accidental spillages and from chronic oil pollutants and pipeline construction. In the absence of tanker operations, accidental oil discharges will be restricted to oil washed ashore from unforeseen platform accidents or pipeline rupture. Chronic pollutants may result from pipeline leaking and refinery effluents. St. Amant views chronic pollution as posing greater environmental jeopardy than the more obvious damage which results from accidental oil spills. To quote St. Amant (1972) directly:

Significant ecological or environmental damage must be viewed as a permanent or long term change in the ecosystem that reduces its efficiency and subtracts from its overall productivity. Such a change may be the result of sudden catastrophic events with obvious results; more often, it represents the long term cumulative effects of apparently innocuous happenings and of chronic mismanagement of the environment.

While little has been done to methodically answer ecological questions concerning effect of hydrocarbons on highly productive marshland ecosystems, some recent advances have been made. It has been established that large inputs of petroleum into marshlands may result in immediate faunal mortalities and the retarding of floral species.

For example, British studies of salt marsh oiling followed a "moderately severe" spill of crude oil from the tanker Chryssi P. Goulandeis in Milford Haven estuary, Wales (Baker, 1971; Cowell, 1969; Cowell and Baker, 1969). A survey two weeks after the spill showed that oily saltmarsh vegetation had yellowed and was dying although new green growth was showing at the base of some species. Some plant communities remained without new growth a year later. While observa-

tions were not made on saltmarsh fauna, mortality was presumed high for aquatic animals in the spill area.

Baker (1971) sprayed saltmarshes in southwest Wales with fresh Kuwait crude oil at different times of the year. Results indicated that a light pollution with crude caused little long term damage to most salt marsh plants, whatever time of the year the pollution occurred, although most damage occurred in warm months. Oiled leaves died but perennial plants recovered well with new growth; annual plants were severely reduced in numbers because they could not recover by new growth before fall. Seed production of annuals was inhibited for one season.

Mackin, (as cited in Stone, 1972) studied the effects of crude oil on a number of Louisiana marsh grasses. The species included saltgrass, *Distichilus spicata*, cordgrass, *Spartina alterniflora*, and Bates grass *Batis sp.* which are the dominant species in the fresh and brackish marshes. Mackin's data strongly implies that long term exposure to petroleum at relatively high concentrations is quite lethal, and that immediate and rapid cleanup is therefore critical and essential (Stone, 1972).

Boesch (1973) notes that while:

...more study and quantification are required, it seems likely that petroleum hydrocarbons, even those not soluble enough to be directly lethal, may inhibit photosynthesis for a short time and under the proper conditions.

The proper conditions refer in part to exposure of plant organisms to petroleum hydrocarbons at concentrations greater than 50 to 100 $\mu\text{g}/\text{l}$ (Gordon and Proust, 1972) as cited by Boesch (1973).

In summary, two relatively unaltered estuaries (Mugu Lagoon and Anaheim Bay) and three altered bays, but having endangered bird species nesting areas (Marina Del Rey, San Pedro Bay, and Alamitos Bay) will be in danger of receiving oil from a large spill which, as in Case 1, will move directly on the mainland shore. If oil from a large spill were to enter an estuary, widespread death and destruction would result. The severity of the destruction would largely depend on the length of time oil remained in the semiencloded estuary, with its restricted circulation, before being cleaned up. Clean-up operations would of course, cause a certain amount of death. The amount of destruction is unquantifiable, while the time for biological recovery will be from one to several years.

6. Marine Mammals

With only minor changes this section was taken from Dailey (1974) of the Southern California Ocean Studies Consortium. Whale sightings mentioned in the text are shown in the consortium report. Breeding and hauling out areas of the pinnipeds are also shown on Graphic 9. A discussion of impacts on marine mammals may be found in Section III.C.3.

a. General Overview

The reported marine mammal fauna of Southern California and the Channel Islands consist of cetaceans, pinnipeds and one carnivore. All three of these groups occur or have occurred in the study area, some as residents and others as transients recorded only by incidental sightings.

The Southern California coast and adjacent offshore islands comprise the most important breeding and hauling out area of the Pacific coast of the continuous United States for pinnipeds, while the surrounding waters are also used extensively by over 20 species of cetaceans.

The cetaceans are represented by both the Mysticeti (baleen whales) and Odontoceti (toothed whales), the latter being by far the most abundant. Of the baleen whales, the Pacific Right Whale* (*Baleana glacialis*) has confirmed sightings in the study area. The five members of the Fin or Rorqual whale group (Little Piked or Minke Whale, *Balaenoptera acutorostrata*; Sei Whale, *B. borealis*; Blue or Sulphur Bottom, *B. musculus*; Finback Whale, *B. physalus*; Humpback Whale, *Megaptera noveangliae*) are listed as transients with confirmed sightings only on the Minke, Sei and Finback. The only common mysticete

*Marine mammal taxonomy follows Rice and Scheffer, 1968.

found in the study area is the California Gray Whale (*Eschrichtius gibbosus*). These migrate annually from their summer feeding areas in the Bering Sea to their breeding grounds in Scammon Lagoon, Baja California, Mexico. Seven species are listed by the U. S. Fish and Wildlife Service (1974) as endangered species (Table II-45).

The toothed whales, which include the propoise and dolphin groups, are represented by 15 species in the study area. Of these, 10 could be listed as common to occasional (Common Dolphin, *Delphinus delphis*; Pacific Pilot Whale, *Globicephala macrorhyncha*; Pacific Striped or White-Sided Dolphin, *Lagenorhynchus obliquidens*; Northern Right Whale Dolphin, *Lissodelphis borealis*; Dall Porpoise, *Phocoenoides dalli*; Long Beaked Dolphin, *Stenella caeruleoalba*; Pacific Bottlenose Dolphin, *Tursiops gilli*; Pygmy Sperm Whale, *Kogia breviceps*) and five uncommon to rare (False Killer Whale, *Pseudorca crassidens*; Pacific spotted Dolphin, *Stenella graffmani*; Sperm Whale, *Physeter catodon*; Hubb's Beaked Whale, *Mesoplodon carlhubbsi*; Cuvier's Beaked Whale, *Ziphius cavirostris*). The most recent, useful and readily available sources of information on Cetacea in the study area can be found in Norris and Prescott, 1961 (Observations on Pacific Cetaceans of California and Mexican waters); Rice, 1963 (The Whale Marking Cruise of the Sioux City off California and Baja California); Daugherty, 1965 (Marine Mammals of California); Rice and Scheffer, 1968 (A List of Marine Mammals of the World); Ingles, 1965 (Mammals of the Pacific States); Anderson and Jones, 1967 (Recent Mammals of the World); and Ridgway, 1972 (Mammals of the Sea, Biology and Medicine). Other than these, there are older lists and scattered papers dealing with individual sitings and museum records.

The scientific names and feeding habits of the six most common predator whales and dolphins (Daugherty, 1966) and the two most common baleen (plankton strainers) whales (Leatherwood, personal communication) are listed below.

Common dolphin
Delphinus delphis bairde-----Predator

Pacific white-sided dolphin
Lagenorhynchus obliquidens-----Predator

Northern right whale dolphin
Lissodelphis borealis-----Predator

Pacific pilot whale
Globicephala macrorhyncha-----Predator

Pacific bottlenose dolphin
Tursiops truncatus gilli-----Predator

Dall porpoise
Phocoenoides dalli-----Predator

Gray whale
Eschrichtius gibbosus-----Plankton Feeder

Minke or Little Piked Whale
Balaenoptera acutorostrata-----Plankton Feeder

Six species of the Order Pinnipedia have been reported from the study area. The California sea lion (*Zalophus californianus*) is the most abundant, followed by the Northern Elephant Seal (*Mirounga angustirostris*), Stellar Sea Lion (*Eumetopias jubatus*), Harbor Seal (*Phoca vitulina*), Northern Fur Seal (*Callorhinus ursinus*), and Guadalupe Fur Seal (*Arctocephalus philippii*).

In addition to the references listed for the cetaceans, several recent additions for the pinnipeds in the Southern California area are: King, 1964 (Seals of the World); Philbrick, 1967 (Proceedings

of the Symposium on the Biology of the California Islands); Odell, 1972 (Studies on the Biology of the California Sea Lion and the Northern Elephant Seal on San Nicolas Island, California); Peterson and Bartholomew, 1967 (The Natural History and Behavior of the California Sea Lion).

The sea otter (*Enhydra lutris*) was also listed from the study area in earlier reports and is the only carnivore represented.

Table II-45

WHALES IN THE STUDY AREA
LISTED AS ENDANGERED
BY THE U. S. FISH AND WILDLIFE SERVICE

Gray Whale	<i>Eschrichtius gibbosus</i>
Blue Whale	<i>Balaenoptera musculus</i>
Finback Whale	<i>Balaenoptera physalus</i>
Sei Whale	<i>Balaenoptera borealis</i>
Humpback Whale	<i>Megaptera novaeangliae</i>
Pacific Right Whale	<i>Balaena glacialis</i>
Sperm Whale	<i>Physeter catodon</i>

b. Annotated Species List

i. Cetaceans

Balaena glacialis - Pacific Right Whale

Range: Inhabits all temperate waters of the world. In the eastern North Pacific Ocean, the Right Whale ranges from Bristol Bay and the Gulf of Alaska south to 50°N latitude during the summer, and from Oregon south to central Baja California during the winter.

Study Area Sitings: Between 1850-1870 whalers took these occasionally off San Diego. More recent sitings include: March, 1955, one sighted at La Jolla; January, 1956, four seen at La Jolla (Figure 12-1, Dailey, 1974).

Population: The Right Whale was originally very abundant, but heavy exploitation, mostly during the 19th century, reduced all populations to near extinction by the turn of the century. The North Pacific Ocean population is estimated at about 250 animals (Wada, 1972).

Life History: Moderately migratory non-gregarious species remaining in high latitude temperate waters during the winter months. Food consists primarily of plankton (copepods) and small fish. The females breed on alternate years with the young being born between January and April, weaning at about 12 months. Age at maturity is not known, but body length is about 15.2 m in males and 15.8 m in females.

Diseases: Amphipoda (*Cyamus erraticus*, *C. gracialis*, *C. ovalis*).

Balaenoptera acutorostrata - Minke Whale

Range: Bering Sea to Baja California and central Mexico.

Study Area Sitings: This species is the most common Balaenopterid in the Channel Island area. They are observed throughout the year but are most abundant during the winter (Walker, pers. comm.). Area sitings have been recorded by Norris and Prescott, 1961 (Figure 12-1, Dailey, 1974).

Population: Unknown for North Pacific but listed as about 200,000 in the southern hemisphere (Report of the Secretary of Commerce, 1973).

Life History: During the summer they inhabit the high latitudes, moving south to warm water during the autumn and winter. They are known to feed heavily on krill (euphausiids), small fish (anchovy, saury) and squid. They attain sexual maturity at about 7-8 years, and calf only once every two years. They are usually seen singly or in small pods (2-5). Norris and Prescott (loc. cit.) state that calves were seen during the winter months indicating the probability that birth was given during this period.

Diseases: Amphipoda (*Cyamus balaenopterae*).

Balaenoptera borealis - Sei Whale

Range: Nearly world-wide. In the eastern North Pacific it summers from Alaska to California.

Study Area Sitings: Rice (1963) records the siting of one Sei Whale behind San Clemente Island on November 17, 1962. (Figure 12-1, Dailey, 1974). This indicates their presence in these waters and that they are probably more prevalent than sitings would indicate.

Population: The Report of the Secretary of Commerce (Administration of the Marine Mammal Protection Act of 1972, December 21, 1972 to June 21, 1973) lists stock sizes available for commercial harvest are estimated to be about 80,000 in the southern oceans and 33,000-37,000 in the North Pacific Ocean. This estimate does not consider unharvestable young whales. In this report the Sei Whale is listed

as the second most valuable baleen whale, and that its populations appear to be near the level of maximum sustainable yield.

Life History: The diet of this species consists of euphausiids, copepods, sauries, anchovies, herring, sardines and jack mackerel. Sei Whales usually travel in small pods (2-5), attain sexual maturity at 6-12 years and females bear calves every 2-3 years. The mating and calving occurs in the winter with gestation lasting one year and weaning takes place at about 7 months past parturition.

Diseases: Trematoda (*Lecithodesmus* sp., *L. spiosus*, *Ogmogaster plicatus*); Cestoda (*Diphyllbothrium* spp., *Tetrabothrius* sp.); Nematoda (*Anisakis* sp., *A. simplex*, *Crassicauda* sp.); Acanthocephala (*Bolbosoma* sp., *B. turbinella*); Copepoda (*Penella balaenoptera*).

The Secretary of Commerce report (loc. cit.) mentions a unique disease (found in 7% of those taken in California) which causes a progressional shedding of the baleen plates and their replacement by an abnormal papilloma-like growth.

Balaenoptera physalus - Finback or Fin Whale

Range: Nearly world-wide. In the eastern North Pacific it summers from California to the Chukchi Sea.

Study Area Sitings: The only published siting is by Rice (loc. cit.), who reports siting about 57 Fin Whales in 23 pods during the month of November, 1962. All but a few were recorded in waters southwest of San Clemente Island (Figure 12-1, Dailey, 1974).

Population: The report from the Secretary of Commerce (loc. cit.) gives an estimated 120,000 Fin Whales (of harvestable size) world-wide.

Of this number, 10,000-13,000 are estimated from the North Pacific area. In the same report they state that the Fin Whale is commercially the most valuable baleen whale and that stocks in the North Pacific and southern oceans are below maximum sustainable yield levels.

Life History: This species is second only to the Blue Whale in size, reaching a length of at least 23.2 m. It feeds mostly on euphausiids but often takes fish, especially anchovies. They usually travel in small pods of 2-5 animals. They reach sexual maturity at 6-12 years, and the females bear calves every 2-3 years. Mating and calving occurs in winter with the gestation period lasting one year followed by weaning at about 7 months.

Diseases: Amphipoda (*Cyamus balaenopterae*); Trematoda (*Lecithodesmus goliath*, *Ogmogaster antarcticus*, *O. plicatus*, *O. trilineatus*); Cestoda (*Phyllobothrium delphini*); Nematoda (*Anisakis* sp., *Crassicauda* sp., *C. pacifica*); Copepoda (*Penella balanopterae*).

Eschrichtius gibbosus - California Gray Whale

Range: Bering Sea and Arctic Ocean to Baja California.

Study Area Sitings: Seen commonly from December-April traveling south along the California coast.

Population: Since the latter half of the 19th century it has been no longer profitable to hunt them. In 1938 they were given complete protection by international treaty. Adjusted counts taken from 1969-1970 totaled 10,906 animals (Rice and Wolman, 1971). It is estimated that the population has a consistent increase of about 11%

a year. Leatherwood, et al. (unpublished) lists this whale as the most abundant Mysticeti from Pt. Conception to Ensenada.

Life History: Gray Whales usually travel within a few miles of shore while migrating from their summer grounds in the Bering and Chukchi Seas to their winter grounds along the coast of Baja California. The northward migration tends to follow the same course, except females and calves travel offshore. Feeding consists of benthic amphipods of which *Ampelisca macrocephala* predominates (Rice and Wolman, loc. cit.). Virtually no feeding takes place during the migration through Southern California waters and little evidence is found that they feed after arriving at their winter grounds. The peak of breeding takes place in December with gestation lasting about 13 months. Lactation lasts an average of 7 months ending in August.

The Killer Whale (*Orcinus orca*) appears to be the only predator of this whale. The number killed per year is unknown but tooth scars of unsuccessful attacks are frequently seen. There is an inference that the number of sightings are declining due to increased boat traffic in the Catalina Channel. Whales are now passing off the backside of Catalina (Walker, pers. comm.).

Diseases: A high percentage of ectoparasitic infections are reported by Rice and Wolman (loc. cit.): the barnacle *Cryptolepas rhachianecti* found on 100% of the animals examined followed by whale lice, *Cyamus scammoni* (99.7%), *C. ceti* (99.4%) and *C. kessleri* (98.1%) Endoparasites reported are: Trematoda (*Lecithodesmus goliath*, *Ogmogaster pentalineatus*, *O. antarcticus*); Cestoda (*Priapocephalus* sp., *Tetrabothrius* sp.); Nematoda (*Anisakis simplex*); Acanthocephala

(*Corynosoma* sp., *Bolbosoma* sp.). The liver fluke, *L. goliath*, was the only parasite to cause any pathogenic affect.

Pseudorca crassidens - False Killer Whale

Range: Widely distributed in the temperate waters of the Northern and Southern Hemispheres. But on the west coast it occurs from Puget Sound, Washington to Acapulco, Mexico. The distribution of this species closely resembles that of the Pilot Whale, but the latter penetrates deeper into the polar regions.

Study Area Sitings: A total of six skulls of this animal have been found on San Nicolas Island between 1940 and 1960. Mitchell (1965) considers this as evidence of a mass stranding. Also, in 1959 a school of about 300 was seen near Santa Catalina Island. In October, 1963, 200-300 animals were seen 4 miles off Palos Verdes Peninsula and one 11-foot female was captured by Marineland of the Pacific. Judging by strandings, the False Killer Whale appears in the coastal zone very irregularly (Figure 12-2, Dailey, 1974).

Population: There is no data on the current population of this species, but judging by the size of the stranded schools, it exists in considerable abundance.

Life History: Movement of this species occurs in large groups. Food primarily consists of cephalopods and fishes. In stranded schools, males and females occurred in equal numbers. From necropsy evidence, it appears that *P. crassidens* mates during the winter (December) as a nearly full-term fetus was found in November.

Diseases: Two species of trematodes (*Nasitrema attenuata* and

N. globicephalae) have been recorded from this host off the western coast of North America.

Orcinus orca - Killer Whale

Range: In the Pacific they are known to range from Alaska to Costa Rica but are considered a cosmopolitan species.

Study Area Sitings: These whales are seen occasionally in the Catalina Channel and around the Channel Islands during the entire year; predominantly during Gray Whale migrations (Walker, pers. comm.).

Population: No data on population figures have been reported. However, since they have no known natural predators and are not hunted commercially locally, it can be assumed with some certainty that a large stable population exists. Their only enemy is man.

Life History: Killer Whales have no reported migration pattern but wander the seas in large groups. Feeding behavior of Killer Whales have been documented (Tomilin, 1957). Stomach samples have shown numerous types of fish, including sharks, also penguins and other sea birds as well as almost all representatives of the cetacea and pinniped groups. Killer Whales are voracious feeders. According to Eschricht, 1862 (in Tomilin, loc. cit.), a 180 x 130 cm stomach of a 6.5 m whale yielded five or six seals and semidigested remnants of 6-7 more seals and 13 porpoises; in addition, two almost intact seals were found in the esophagus of the Killer. Killer Whales hunt in packs and seem to prefer Gray Whales and various pinnipeds but apparently attack any sea animal that can't outswim them. Breeding has been recorded from March and April through July (Scheffer and Slipp, 1948). Gestation is about one year after which the calf leaves the mother.

Diseases: The most frequent non-parasitic disease listed is a tooth infection caused by the wearing down of the tooth crowns. The animal then suffers from jaw abscesses. The stomach roundworms of the genus *Anisakis* are the only internal parasite recorded from the west coast of North America. Scheffer and Slipp (loc. cit.) reported 5,000 of these worms from a single Killer Whale stomach.

Globicephala macrorhyncha - Pacific Pilot Whale

Range: Alaska to Central and Southern America.

Study Area Sitings: Seen fairly commonly in the Catalina Channel at all times of the year, being most abundant during squid season (April-June) (Walker, unpublished). Last documented strandings were on January 18, 1971, at Pyramid Cove, San Clemente Island (17 animals) (John Hall, pers. comm.).

Population: No population figures are available but numerous sitings would indicate a large, stable population in the Southern California area (Walker, pers. comm.). Pilot Whales are still taken commercially in Japan. Leatherwood et al. (unpublished) lists this whale as the fourth most abundant Odontoceti from Pt. Conception to Ensenada.

Life History: Pilot Whales travel offshore, usually in pods of 15-25 animals. Their main diet consists of cephalopods (squids) and gregarious fishes. Pilot Whales appear in bays and lagoons on rare occasion, as a result of following schools of fishes during feeding. Their main breeding season is during the summer months with gestation and lactation lasting about a year each.

Diseases: Two trematodes (*Nasitrema globicephalae*, *N. lanceolata*) are reported from this whale off the west coast of North America. A nematode (*Anisakis*) was commonly found in captured specimens at Marineland (Walker, pers. comm.).

Mesoplodon carlhubbsi - Hubbs's Beaked Whale

Range: North Pacific Ocean

Study Area Sitings: There are only three published California records: One from a stranding at La Jolla, San Diego Co., in 1945, and two from Northern California (Drakes Bay, Marin Co., 1950; San Simeon, San Luis Obispo Co., 1962). (Figure 12-2, Dailey, 1974)

Population: Considered rare throughout its range. No population estimates available.

Life History: No information available.

Diseases: A specimen stranded in Santa Barbara (May 2, 1972) was infected with three parasites: *Penella* sp., *Phyllobothrium* sp., and an unidentified trematode in the liver.

Ziphius cavirostris - Cuvier's Beaked Whale

Range: Occurs in all oceans. Recorded from Alaska to California on the western coast of North America.

Study Areas Sitings: Five reports of one each from the following: Del Mar, San Diego Co., 1945; Santa Catalina Island, 1957; North Island, San Diego Bay, 1957; Newport Beach, 1963, siting at sea 33°26'N, 119°19'W, 1964. (Figure 12-2, Dailey, 1974).

Population: No published numbers on population but appear regularly in Japanese waters (Nishiwaki, 1972).

Life History: This species reaches a maximum of 6.4 m. Its life history has been little studied but it reportedly feeds on squid (preferably), fish, sea cucumbers, crabs and starfish. Information on mating is not available but calving is thought to take place primarily in the fall (full-term fetuses have been found in August and September according to Tomilin, loc. cit.). These animals travel in small groups and are not conspicuous.

Diseases: Only nematodes from the genus *Anisakis* have been reported from this host on the west coast of North America. However, the larval tapeworm *Phyllobothrium* sp. and two other tissue roundworms of the genus *Crassicauda* are reported from the general literature.

Kogia breviceps - Pygmy Sperm Whale

Range: This species occurs world-wide in temperate and tropical waters.

Study Area Sitings: This species is rarely observed at sea in the study area. There have been fewer than 100 records of it since its description in 1871. Nine recorded sitings are listed in Daugherty (1965) during the last 38 years. Eight of these were from Southern California. All but two of the sitings were from the San Diego area. One from Cabrillo Beach, San Pedro (1960) and a 1966 stranding in the Santa Monica/Playa del Rey area (Walker, pers. comm.).

Population: The industrial yield of the Pygmy Sperm Whale is very small. This, in conjunction with rare sitings, make it impossible to estimate its population.

Life History: Small whales reaching a maximum size of 4 meters. The food of this species is very little known as is its biology in general. From stomach samples it apparently feeds on squid, fish and crabs. Breeding is thought to occur in late summer with parturition taking place in the spring after only 9 months. May is suggested but this is questionable according to Anderson and Jones (1967).

Diseases: There are no reports from animals collected on the west coast of North America but two larval species of Cestoda (*Phyllobothrium delphini*, *Monorgyia grimaldi*) and five species of Nematoda (*Anisakis simplex*, *Crassicauda magna*, *C. duguyi*, *Phocanema* sp., *Pseudoterranova kogiae*) are listed for this host by Dailey and Brownell (1972).

Physeter catodon - Sperm Whale

Range: Listed in the Pacific as ranging from Alaska to South America. On a world-wide basis they exist from 70°N to 70°S. Unlike other cetaceans, the ranges of male and female sperm whales do not coincide: the distribution of the females is much narrower, not exceeding, as a rule, the limits of the tropical and sub-tropical zone. The majority of Sperm Whales inhabit the zone extending from 40°N to 40°S latitude.

Study Area Sitings: There have been two records of the Sperm Whale in the study area. One siting from mid-Catalina Channel in July, 1971 (Walker and Poorman, pers. comm.). A stranded male (59-foot) between Oceanside and Camp Pendleton on December 27, 1972 (Don Patten, pers. comm.). (Figure 12-3, Dailey, 1974).

Population: There is no estimate of the population size of the world. The North Pacific population is estimated at 70,000-100,000 animals according to Nishiwaki (loc. cit.). Tomilin (loc. cit.) states that over 11 years of whaling (1919-1929) off the western coast of North America, 1,217 Sperm Whales were taken out of the total 15,985 whales of various species. Of these only 22 were from lower California. Their numbers can be considered negligible in Southern California waters.

Life History: These are large whales reaching to 19 m. in length. The main diet of Sperm Whales consists primarily of cephalopod molluscs. Fishes appear to be of little importance being chiefly in inshore waters. Among fishes, the prominent food items are elasmobranches (mostly skates, less often sharks), the teleosts being only of secondary importance. Other food, including small pinnipeds, are swallowed accidentally or when no other food is available. In the Northern Hemisphere, April is the peak of the breeding season with parturition occurring after a 16-month gestation period. Lactation lasts about 13 months with sexual maturity reached at about 8-9 years. Sperm Whales are believed to live a maximum of 70 years.

Diseases: Jaw abscess from tooth wear has been reported as has eye infection. Skin lesions caused by ectoparasites (diatoms; amphipods - *Cyamus catodontis*, *Neocyamus physteris*; barnacles) are reported as a major problem. Endoparasites include cestode larval forms (*Phyllobothrium delphini*) and nematodes (*Anisakis* spp., *Placentonema gigantissima*).

Tursiops gilli - Pacific (Gill's) Bottlenose Dolphin

Range: Pacific Ocean. Most abundant in the North Pacific.

Study Area Sitings: Seen occasionally in the Catalina Channel in numbers increasing in the Baja and Sea of Cortez area. This is considered to be primarily a Mexican species which never goes much farther north than Santa Monica Bay. Several specimens have been seen in San Diego Bay (1956-1958) and off Palos Verdes Peninsula (1956) (Norris and Prescott, loc. cit.). (Figure 12-3, Dailey, 1974)

Population: Herds of several hundreds are reported so this species is presumed to exist in fairly high numbers, although no census data is available. Leatherwood, et al. (unpublished) lists this dolphin as the fifth most abundant Odontoceti along with *P. dalli* from Pt. Conception to Ensenada.

Life History: This species is coastal and tends to stay close to shore. They have been known to go up rivers as well as enter bays and lagoons. *T. gilli* feed primarily on fish but may also take squid and shrimp. Breeding takes place in the spring and early summer with the young being born in 12-13 months. A fall breeding may also take place for those unsuccessfully impregnated during the spring. The life span is estimated at 25-30 years.

Diseases: There are three disease agents reported from *T. gilli*. The trematode, *Nasitrema* sp., and nematode, *Crassicauda* sp., from the air sinuses and the lungworm, *Halicercus* sp., from the respiratory system.

Delphinus delphis - Common Dolphin

Range: Occurs world-wide. Found from British Columbia to Baja California on the west coast of North America.

Study Area Sitings: Found abundantly offshore throughout the study area. Telemetric studies indicate that these dolphins are more common over or near underwater seamounts, ridges, etc. (Evans, 1971).

Population: Estimated at more than 30,000 by Nishiwaki (loc. cit.) but this is probably a conservative estimate. Leatherwood, et al. (unpublished) lists this dolphin as the most abundant cetacean from Pt. Conception to Ensenada.

Life History: *D. delphis* feeds chiefly on schools of migrating fish (herring, anchovies, sardines, etc.) and squid (beaks always present in stomach). Food preferences are similar to the white-sided dolphin (Walker, pers. comm.). Sexual maturity is reached in females at 3 and males at 4 years. Mating takes place in the fall with gestation lasting 10 months. Females migrate offshore in summer and calve in open sea. Individuals are assumed to live 25 to 30 years.

Diseases: This species is the most commonly found stranded (beached) animal in the study area. Stranded animals are found to be heavily parasitized with trematodes of the genus *Nasitrema*. Massive brain lesions are caused by this fluke resulting in the loss of equilibrium and most probably echolocation ability (Ridgway and Dailey, 1972). The larval cestodes *Phyllobothrium delphini* and *Monorygma* are found commonly in the blubber and peritoneal cavity, respectively

(Walker, unpublished). Gastric ulcers were observed by Brown and Norris (1956), with the probable etiological agent being stress. One case of parasitic peritonitis is reported caused by heavy infection of *Anisakis* - Dailey and Walker (in press).

Lagenorhynchus obliquidens - Pacific Striped or White-Sided Dolphin

Range: Found in the North Pacific, abundant in Japanese waters and along the west coast of North America.

Study Area Sitings: Very abundant in the Catalina Channel and throughout Southern California offshore waters.

Population: Schools up to 1,000 animals have been reported. Nishiwaki (loc. cit.) estimates the species near Japan alone to number between 30,000-50,000. Leatherwood, et al. (unpublished) lists this dolphin as the second most abundant Odontoceti from Pt. Conception to Ensenada.

Life History: This species moves in large herds feeding on squid preferably but also taking small pelagic fishes. The breeding season and parturition occurs from spring to summer. These animals keep well in captivity and are used extensively as show animals in oceanaria.

Diseases: No external, gross diseases have been noted for this species. However, like *Delphinus delphis*, it is commonly found stranded during the spring and summer months. Massive brain lesions involving the parasites *Nasitrema* (both eggs and adults) have also been found in these beached animals by Dailey and Walker (unpublished). The transmission of this fluke is unknown at the present time.

Lissodelphis borealis - Northern Right Whale
Dolphin

Range: North Pacific-Bering Sea to Southern
California.

Study Area Sitings: Actual specimens reported are: Torrey
Pines, San Diego, 1956, Manhattan Beach, 1960; Marineland of the
Pacific has occasional sitings in the Catalina Channel and around the
Channel Islands from February to May. One was captured by Marineland
for exhibition in 1973 (pers. obser.) However, they are not seen
commonly (Walker, pers. comm.). (Figure 12-4, Dailey, 1974).

Life History: This species feeds mainly on squid and pelagic
fish. They generally form large herds, are very fast swimmers
(35 km/hr) and avoid boats. Little work has been done on the breeding
behavior of this animal.

Population: The population is estimated at more than 10,000
animals. Leatherwood, Green and Walker (unpublished) lists this
species as the third most abundant Odontoceti from Pt. Conception to
Ensenada.

Diseases: The helminth parasites of *Nasitrema globicephalae*,
Penella sp. (heavy), *Monorygma*, *Phyllobothrium*, *Crassicauda*, and
Anisakis are reported from this host (Dailey and Walker, in press).

Phocoena phocoena - Harbor Porpoise

Range: Although this species is very common in
the North Atlantic it is also widely distributed in other parts of
the world. In the Eastern Pacific they range from Pt. Barrow, Alaska
to central California and occasionally into Southern California.

Study Area Sitings: Extremely rare. One reported from Los Angeles Harbor (Daugherty, loc. cit.) and one living specimen from Oxnard-Pt. Hueneme taken in a gill net on May 3, 1963 (Walker, pers. comm.). (Figure 12-4, Dailey, 1974)

Population: Abundant in the North Atlantic and Eastern North Pacific.

Life History: *P. phocoena* feeds on fish, squid and crustaceans. Breeding takes place in July and August followed by a 9-10 month gestation period. Harbor porpoises stay in small groups of 2-10 individuals aggregating in large schools only during the run of schooling fishes. They stay near shore and invade bays and lagoons commonly.

Diseases: Two species of trematodes (*Campula oblonga*, *Hadwenius nipponicus*), one larval Cestoda (*Pyramicocephalus phocarum*), three nematodes (*Halocercus invaginatus*, *Pharurus convolutus*, *Stenurus minor*) and one acanthocephala (*Corynosoma alaskensis*) have been reported from this porpoise.

Phocoenoides dalli - Dall Porpoise

Range: Inhabits cold waters of the North Pacific including the Bering Sea and Aleutian chain. They also extend southward to Baja California.

Study Area Sitings: This species is seen in fairly large numbers throughout the coastal zone 10-20 miles offshore. Groups of 5-10 are seen in the Catalina Channel area throughout the year. More abundant in winter and spring months (Walker, unpublished).

Population: Nishiwaki (loc. cit.) states that the population of the northwestern North Pacific may be as many as 50,000 animals. There are no published figures for the large stable population as schools of 100 or more have been reported by Daugherty (loc. cit.). Leatherwood, et al. (unpublished) lists this porpoise as the fifth most abundant Odontoceti along with *T. gilli* from Pt. Conception to Ensenada.

Life History: There is little information on the biology of this species. They apparently feed predominantly on squid and schooling fishes, hake and juvenile rockfish very common. Reproduction periods have not been recorded; however, fetuses found in April and May measured only 30 cm while those found in June were 80 to 90 cm. This would indicate parturition occurs during the summer.

Their behavior indicates they remain in small herds when near shore but form groups up to 1,000 animals in open ocean or at popular feeding grounds.

Diseases: Reports from this species taken in eastern Pacific waters include nematodes (*Anisakis simplex*, *Crassicauda*, *Halocercus kirbyi*, *Placentonema* sp., *Stenurus minor*, *Pharaurus dalli*) and trematodes (*Campula oblonga*, *Nasitrema dalli*). Biliary fibrosis and pulmonary granulomas have been listed from this species as a result of parasitic infection.

Stenella caeruleoalba - Long-Beaked Dolphin or Blue-White Dolphin

Range: Has been reported from the Atlantic and Pacific Oceans, also the Mediterranean Sea. In the Pacific, it has

been recorded from the Bering Sea to Southern California.

Study Area Sitings: The only recorded California sitings are from the study area; one from the vicinity of San Diego; one from a beached specimen near Santa Monica Bay in 1960; and a recent stranding in Long Beach Harbor (at the foot of Junipero Street) occurred on March 21, 1973 (Walker, pers. comm.). (Figure 12-4, Dailey, 1974).

Population: Even though this species is uncommon in Southern California waters, Nishiwaki (loc. cit.) lists the Pacific population at 15,000 to 200,000 animals. The Blue-White Dolphin is taken commercially in limited numbers by the Japanese.

Life History: The primary food of this species is squid with *Loligo* sp. listed as predominant. Two distinct breeding seasons, spring and fall, are reported by Nishiwaki (loc. cit.) with parturition occurring in spring and autumn. Lactation lasts from 6 to 12 months, and sexual maturity attained at four years. This dolphin is reportedly easily frightened by human activity and can be easily herded into bays for harvesting. They are assumed to live from 25-30 years.

Diseases: The cestode larvae *Monorygma* sp. and *Phyllobothrium* sp. are listed as parasites of the mesenteries and blubber, respectively. Also, the nematode *Anisakis* sp. is reported from this host.

Stenella graffmani - Pacific Spotted Dolphin*

Range: This species is very abundant in the eastern tropical Pacific most commonly occurring from Cape San Lucas in Baja California to Columbia, South America. They are rare in Southern California waters.

*This species listed as *Stenella dubia* by Rice and Scheffer, 1968.

Study Area Sitings: There is one record from the vicinity of San Diego, and a very uncertain report of another having been taken by a commercial fisherman in the Channel Islands region (Daugherty, loc. cit.). (Figure 12-4, Dailey, 1974)

Population: This species is seen in very large schools and run with the tuna. For this reason they have been harvested in large numbers with tuna catches. There is concern about their numbers if this practice continues. Special escape nets are now being developed by the National Marine Fisheries Service hopefully to remedy this situation.

Life History: Reproductive information is available in Harrison, et al. (1972). Feeding apparently includes squid and fish. They inhabit open ocean and frequently stay close to ships for hours.

Diseases: Dailey and Perrin (1973) lists 10 genera and 11 species of parasitic helminths found in this porpoise. Severe problems in the pancreatic duct, skull region and colon area are indicated as a result of these infections.

ii. Pinnipeds

Callorhinus ursinus - Northern or Alaska Fur Seal

Range: North Pacific. Bering Sea population extends down to northern Japan and Southern California. Breeding sites are Pribilof Islands, Commander Islands, Kuriles, Robben Island and San Miguel Island, California.

Study Area Sitings: Bartholomew stated in his 1967 report that the Northern Fur Seal is a regular visitor to the offshore waters of

Southern California; but in the normal course of events, no individuals, other than sick or injured ones, come ashore either on the Southern California Islands or on the adjacent mainland. In a 1968 mimeographed report at the University of California, Santa Cruz, R.S. Peterson, R.L. Gentry and B.J. LeBoeuf reported discovery of a breeding colony of 100 animals at San Miguel Island, California. Since that time (1969-1973), observational studies have been conducted on the Adam's Cove, San Miguel Island breeding colony. In 1972, an additional breeding colony was found on Castle Rock, San Miguel Island. Population estimates from ground censuses and aerial photo surveys place the San Miguel Island Northern Fur Seal population at about 800 animals (Robert DeLong, pers. comm.) see Figures II-64 and II-65.

Population: Threatened by extinction due to heavy killing, they were given protection by international treaty in 1911. Since that time the total fur seal population, which was estimated at fewer than 125,000 animals, has risen to 1,500,000-1,800,000 on the Pribilof Islands, and 60,000 and 40,000 on the Commander and Robben Islands, respectively, according to Scheffer, 1968 (in Nishiwaki, 1972). The reestablishment of the small colony on San Miguel Island is considered a direct result of this population recovery.

Life History: This species breeds in large rookeries to which they return every year. The older males arrive on the breeding grounds at the end of May through June to fight for territories. The females arrive later, have their pups and in 5-7 days will breed again. A successful male may attain and hold an average of about 40 females.

The females nurse the pups for three months then leave them and migrate south with young males. This species becomes sexually mature at three years. Sixty types of food has been found in the stomach samples with anchovies, sauries, hake and squid reported to be the most prevalent in California waters. The Northern Fur Seal may live approximately 25 years.

Disease: Mortality rate among pups is very high. Of 232 dead pups examined on Pribilof, malnutrition, liver damage, multiple hemorrhage-perinated complex, hookworm, sarcocystis, and infections were reported as causes (Marine Mammal Biological Laboratory Fur Seal Investigations, 1967; U.S. Fish and Wildlife Service, Spec. Sci. Rep. 597, 1970: 1-104; Brown et al., 1974). Hookworm is estimated to kill up to 20% of the pups. Many more are crushed or maimed by fighting males and panic among adult cows. It is thought that over 50% of the pups perish the first year. Natural enemies are killer whales, sharks and man. Organochlorine pesticides (DDE, DDD, DDT, dieldrin and PCB) levels have been found in adults and nursing pups (Anas and Wilson, 1970).

"It appears that the effects of oil on the pelage of *Callorhinus* may be much more debilitating than that seen for *Zalophus* and *Mirounga*. From the observation of this animal received in December it appears that the net effect of an oil spill off San Miguel Island could be disastrous to the newly established Northern Fur Seal population." (Walker, pers. comm.).

Arctocephalus philippii - Guadelupe Fur Seal

Range: At present the only breeding colony of this

species is on Guadalupe Island off Baja California. They are thought to range both north and south of this site.

Study Areas Sitings: King (1964), Daugherty (loc. cit.) and Nishiwaki (loc. cit.) all indicate incidental sitings of this species near Santa Barbara Island (1929) (Figure II-64) and on San Nicolas Island (1949) Figure II-67. R.L. DeLong (pers. comm.) reports siting a few visitant males at San Miguel Island each year between 1969-1973 (Figure II-66). There are indications by Indian middens that at one time this species was more abundant on San Miguel Island than *C. ursinus* (Repenning, Peterson and Hubbs, 1971). See Figure II-64.

Population: This species was once thought to be extinct but now thought to be about 500 animals (Peterson et al., 1968, in Nishiwaki, loc. cit.).

Life History: Due to the extremely small population, little is known of this animal's feeding habits or reproductive behavior. However, it is thought to be similar to the Northern Fur Seal.

Diseases: None reported.

Zalophys californianus - California Sea Lion

Range: From Vancouver Island, British Columbia to the Tres Marias Islands off Mexico. Breeding grounds are primarily the Southern California offshore islands.

Study Area Sitings: This is the most common pinniped in the study area and is found throughout the year. Peak population occurs during spring and early summer (see Figure II-64).

Population: Census information taken by aerial photographs (Odell, 1971) indicate that during June, 1964, there were at least 34,382 animals on the Channel Islands. Of these 29,784 were adults and immature with 4,598 pups. The largest population occurred on San Miguel (14,351) (Figure II-66) followed by San Nicolas (12,748) (Figure II-67) San Clemente (3,820), Santa Barbara (2,282). Santa Catalina (92), and Santa Cruz (89). None were reported from Anacapa and Santa Rosa Island. On San Nicolas Island the *Zalophus* population is reported to have two yearly peaks (Odell, 1972): a winter peak with 9,000-11,000 animals and a breeding peak with 10,000-12,000 animals. Odell (1971) indicates that his data suggests the population may have stabilized.

Recent censuses by the California Department of Fish & Game are shown on Table II-46 (Carlisle and Aplin, 1971).

Life History: On San Nicolas Island the *Zalophus* males begin to occupy territories in late May at the same time the first pups are born on the rookeries. The territory is maintained an average of 27 days and covers about 130 m². The first copulations are reported by Odell (1972) on June 12 and last until about July 25. Sixty percent of the copulations are aquatic. The interval between parturition and copulation was 15 to 30 days.

After the breeding season there is a marked difference between the changes in seasonal distribution of males and females (Bartholomew, 1967). During fall and winter, the adult males migrate to the north while the females and immatures move south. There is also a small

resident population which stays in the Channel Island area. The *Zalophus* diet consists largely of squid, octopus and a variety of fishes, the latter being chiefly non-commercial.

This species shows remarkable fear of humans. The sight of a person will cause all animals on a rookery to stampede into the water. Continued disturbance will cause animals to abandon traditional rookery areas (Peterson and Bartholomew, 1967; Odell, 1972).

Diseases: There are numerous parasitic organisms reported from this animal (Margolis and Dailey, 1972; Dailey and Brownell, 1972; Smith et al., 1974) but a hookworm of the genus *Uncinaria* and the lungworm *Parafilaroides decorus* and *Leptospira* sp. appear to cause the most damage. The mortality rate among pups is estimated at approximately 50% (Daugherty, loc. cit.). During the last several years premature pupping (abortion) has become an area of concern. On San Nicolas Island, Odell (1972) reports the number of aborted pups counted in 1969, 1970, and 1971 were 135, 442, and 391, respectively. The cause or causes for this condition have been examined by several authors (DeLong et al., 1973; Brownell and LeBoeuf, 1970; Simpson and Gilman, 1970) and results indicate it could possibly be induced by chlorinated hydrocarbon residues or microorganisms. Also, during the last several years leptospirosis has been listed as the cause of death in beached animals (McIlhatlan et al., 1971).

Eumetopias jubatus - Stellar or Northern Sea
Lion

Range: From the Bering Strait, Alaska to Southern California. Breeding grounds extend throughout most of the range.

Study Area Sitings: The northern species is found as a breeding colony only on the western tip of San Miguel Island (Figures II-64 and II-66). Only a few animals are seen year-round in the study area.

Population: Nishiwaki (loc. cit.) states a total count of this species at 250,000-300,000 animals. In the study area, Robert DeLong (pers. comm.) has observed approximately 75 animals on San Miguel Island with fewer than 20 pups being born between 1969-1973.

Life History: The breeding season begins in early May with the arrival of adult males to establish territories. The females arrive two or three weeks later, harems are formed (10-20 females/bull) and pups are born within several days. Mating takes place shortly after parturition (between late May and early June) but blastocyst implantation does not take place until October. Breeding colonies break down in August with the herd going to sea, leaving only a remnant population. Males are believed to become sexually mature at five, and females at three years. These are very cautious animals, hauling out on land only where quick escape is possible. Food consists of a wide variety of fish and squid.

These animals are reported to occasionally swim far up rivers. Weed, 1936 in Ingles (1965), reports the capture of a *Eumetopias* in a pasture nearly 75 miles inland near Oregon City, Oregon. This behavior is considered rare by Mate (1973).

Diseases: There are 19 species of parasitic organisms listed for this sea lion from the west coast of North America by Margolis and Dailey (loc. cit.): 1 trematode, 4 cestodes, 7 nematodes, 2 acanthocephalans, 2 Anoplura, and 3 Acarina.

The pathogenicity of any one species has not been documented for this host but it could be assumed that the hookworm in pups is capable of causing severe problems.

Mirounga angustirostris - Northern Elephant Seal

Range: From Alaska (Prince of Wales Island)
to Baja California.

Study Area Sitings: Seen throughout the year in the Channel Islands and occasionally hauled out on the mainland (Figure II-65).

Population: This species was almost exterminated by commercial sealers in 1860. By 1890 the only known survivors consisted of a small group (between 20-100 animals) hauled out on the northwest coast of Guadalupe Island off the Baja peninsula. The 1964 aerial census for the Channel Islands showed a total of 2,158 animals (Odell, 1971). These animals were distributed between San Miguel (1,922) (Figure II-66) San Nicolas (197) (Figure II-67, and Santa Barbara (39) Islands. In 1972, California Fish and Game counted 3,470 animals with an estimated pup production of 2,500-3,000 over the last three years (Robert DeLong, pers. comm.) bringing the current total to above 6,000 animals. Nearly five doublings in 80 years--average doubling time approximately 16 years or $4\frac{1}{2}\%$ compound growth rate. The *Mirounga* population on San Nicolas Island has three yearly peaks according to Odell, 1972: an immature peak in November, a breeding animal peak in early February, and a molting peak in April. The breeding and molting peaks contained 393-719, 467-776, and 702-1,050 in 1969, 1970, and 1971, respectively. The number of pups born in these years was 193, 210, and 344, respectively. Pup mortality on land was 3-4% in 1970 and 1971.

Recent censuses conducted by the California Department of Fish and Game are presented on Table II-47a (Carlisle and Aplin, 1971). According to Carlisle (1973) the population on San Miguel Island has stabilized at around 3,500 since 1971 through 1973.

Life History: The overall breeding season is from December to March with the peak in January and February. During this period and in early spring the greatest number of animals come ashore. Territories containing from one to several hundred females are formed, where pupping and copulation take place. Gestation is 11 months. This species appears to be pelagic during much of the year with some individuals migrating long distances from the breeding grounds. The marked seasonal differences in the relative numbers of males and females on the hauling grounds suggests that the two sexes have different patterns of seasonal movement. The Northern Elephant Seal appears to show an unusual degree of indifference to man that is characteristic of many insular vertebrates. However, persistent human disturbance will cause animals to abandon beaches.

The spectacular population growth of this species is one of the most dramatic demonstrations of population recovery known for any large mammal.

Diseases: No diseases are recorded for *Mirounga* but there are 7 species of parasites listed for this seal by Dailey and Brownell (loc. cit.). Of these, the most common pathogens seem to be the stomach worms *Anisakis similis* which cause large ulcerations and ensuing enteritis (pers. obser.), also lungworms of two genera,

Halocercus and *Parafilaroides* (Dailey, unpublished).

Phoca vitulina - Harbor Seal

Range: Two subspecies are listed by Daugherty (1965) as making up the Pacific population. The northern form ranges from Herschel Island and the Bering Sea south to Monterey County; while the southern counterpart exists from Santa Barbara south to San Geronimo Islands, Baja California.

Study Area Sitings: This species occurs throughout the year on the offshore islands (Figure II-65), with the largest populations on San Nicolas (Figure II-67) and San Miguel (Figure II-66).

Population: Scheffer (1958) gives the world population of Harbor Seals at 150,000 to 450,000 animals. Of this total, he lists the southern California species at 20,000 to 50,000. Daugherty (loc. cit.) states that only about 500 individuals are in California. Odell (1971) reports the 1964 census (total count from all of the Channel Islands) as 645. All counts were taken in June and were represented as follows: San Nicolas - 95, San Miguel - 78, Anacapa - 39, Santa Cruz - 114, Santa Rosa - 167, Santa Barbara - 0, San Clemente - 6, and Santa Catalina - 107. The numbers hauling out on beaches, in bays, etc., have not been reported. Robert DeLong (pers. comm.) reports that about 300 *Phoca* were observed on San Miguel during 1973.

Recent censuses by the California Department of Fish and Game are shown on Table II-47b (Carlisle and Aplin, 1971).

Life History: Harbor Seals breed in September, and usually a single pup is born on land or rarely in water in early spring (April-May). This species does not form harems but are polygamous. The

pups nurse from 3-6 weeks and are good swimmers soon after birth.

Their food consists of fish, squid, octopus, and some shellfish.

Diseases: Reports of diseases in this animal are negligible; however, a large number of internal parasites have been reported from *Phoca* on the west coast of North America. These include the trematode (*Phocitrema fusiforme*), cestodes (*Diphyllbothrium alascense*, *D. lanceolatum*, *D. osmeri*), nematodes (*Contracaecum osculatum*, *Dipetalonema spirocauda*, *Terranova decipiens*), and acanthocephalans (*Corynosoma falcatum*, *C. demerme*, *C. strumosum*, *C. wegneri*).

iii. Carnivores

Enhydra lutris - Sea Otter

This mammal no longer exists along the Southern California coast but is included here because of past representation. The Sea Otter was the most sought after of marine fur bearers during the 18th and 19th centuries; and like the pinnipeds, it was virtually exterminated by commercial hunters early in the 19th century. Prior to that time it apparently abounded along the Southern California coast as far south as Baja California. The remnant California population is now found only from the Monterey Bay area south to Morro Bay. Bartholomew (1967) states, however, that there is every reason to be optimistic that a population may again ultimately reestablish itself in the northern parts of the California Channel Islands if the habitat continues to remain relatively undisturbed and effective protection is afforded from hunters and abalone fishermen.

TABLE II-46

COMPARISON OF SEA LION DISTRIBUTION ON ROOKERIES AND
HAULING GROUNDS, 1958, 1961, 1965, 1969 AND 1970 From: Carlisle (1971)

	1958	1961	1965	1969	1970
St. George Reef to Cape Mendocino-----	1,321	907	625	1,069	1,026
To Pt. Arena-----	1,050	781	278	552	402
To Pt. Reyes-----	936	795	259	420	197
To Pigeon Point-----	90	23	--	263	68
Farallon Islands-----	941	703	311	855	585
Pt. Ano Nuevo-----	1,170	2,342	2,574	1,985	1,542
To Pt. Lobos-----	517	230	317	488	265
To Pt. Conception-----	1,028	894	634	1,524	1,104
Northern California-----	7,053	6,675	4,998	7,156	5,189
To Pt. Loma (mainland)-----	164	33	67	37	39
San Miguel Island-----	5,192	9,512	11,641	7,734	9,835
Santa Rosa Island-----	295	--	125	--	220
Santa Cruz Island-----	262	15	401	317	201
Anacapa Island-----	45	15	--	--	40
Santa Barbara Island-----	1,847	1,760	1,100	654	484
San Clemente Island-----	1,507	2,361	1,900	667	949
Santa Catalina Island-----	233	30	35	107	39
San Nicolas Island-----	3,074	4,637	1,900	7,935	6,240
Southern California-----	12,672	18,363	17,169	17,451	18,047
Total California-----	19,725	25,038	22,167	24,607	23,236

TABLE II-47a

DISTRIBUTION OF NORTHERN ELEPHANT SEALS DURING
1965, 1969 AND 1970 CENSUSES From Carlisle (1971)

	1965	1969	1970
Point Ano Nuevo	363	172	85
San Miguel Island	3,000	1,451	2,917
San Clemente Island	100	--	--
San Nicolas Island	100	191	--
Total	3,563	1,642	3,005

From: Carlisle (1971)

TABLE II-47b

DISTRIBUTION OF HARBOR SEALS DURING 1965, 1969 AND 1970

	1965	1969	1970
St. George Reef to Cape Mendocino	56	167	421
To Point Arena	304	409	227
To Point Reyes	78	454	591
To Pigeon Point	250	204	114
Pt. Ano Nuevo	--	172	88
To Point Lobos	94	41	75
To Point Conception	70	151	148
To Point Loma	--	7	--
San Miguel Island	140	64	--
Santa Rosa Island	--	209	3
Santa Cruz Island	70	168	,8
Anacapa Island	--	93	--
Total	1,062	2,139	1,675

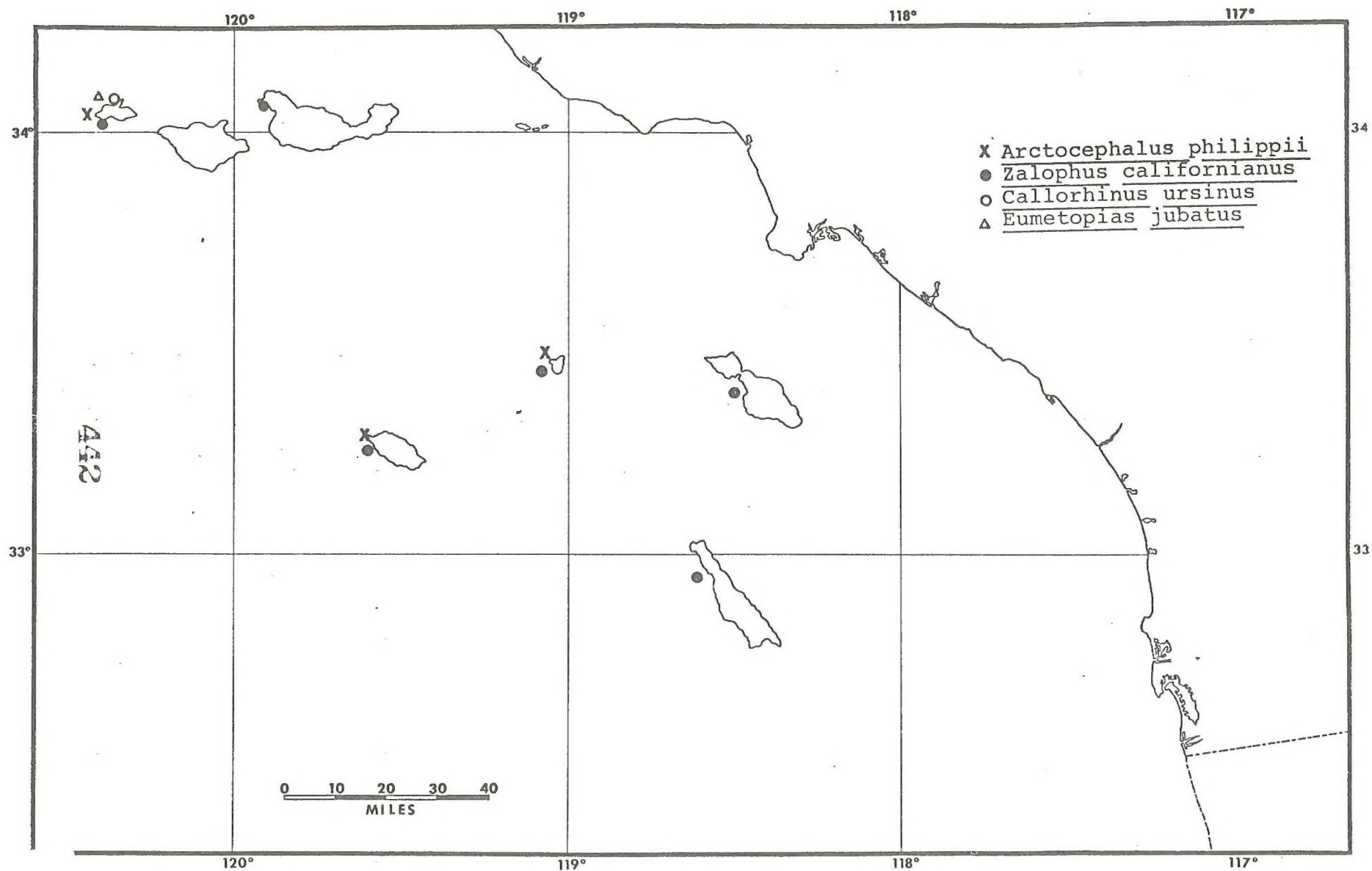


Figure II-64 Location of breeding and hauling out areas of Otariids.

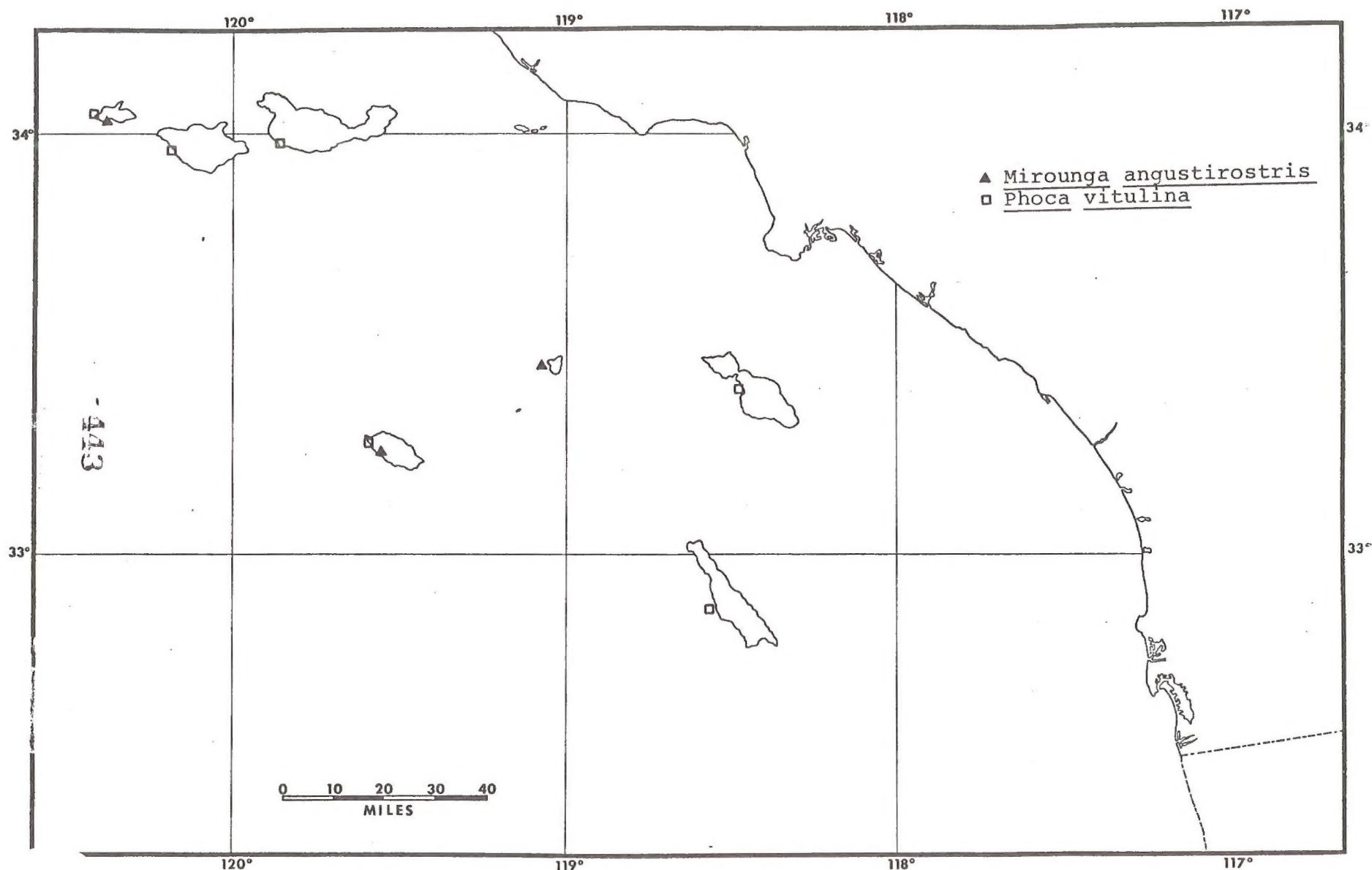


Figure II-65 Location of breeding and hauling out areas of Phocids.

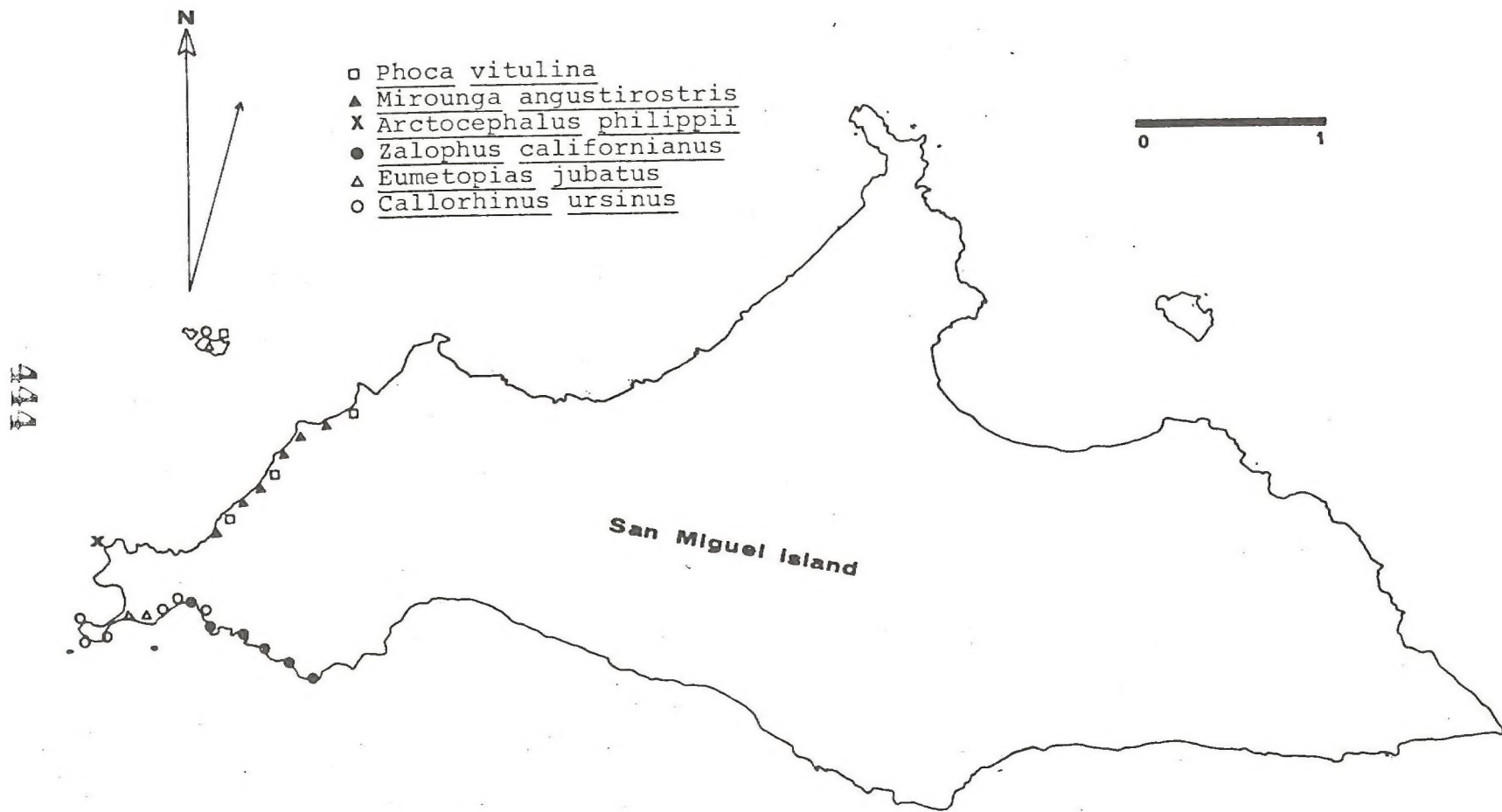


Figure II-66. Location of breeding and hauling out areas of pinnipeds on San Miguel Island.

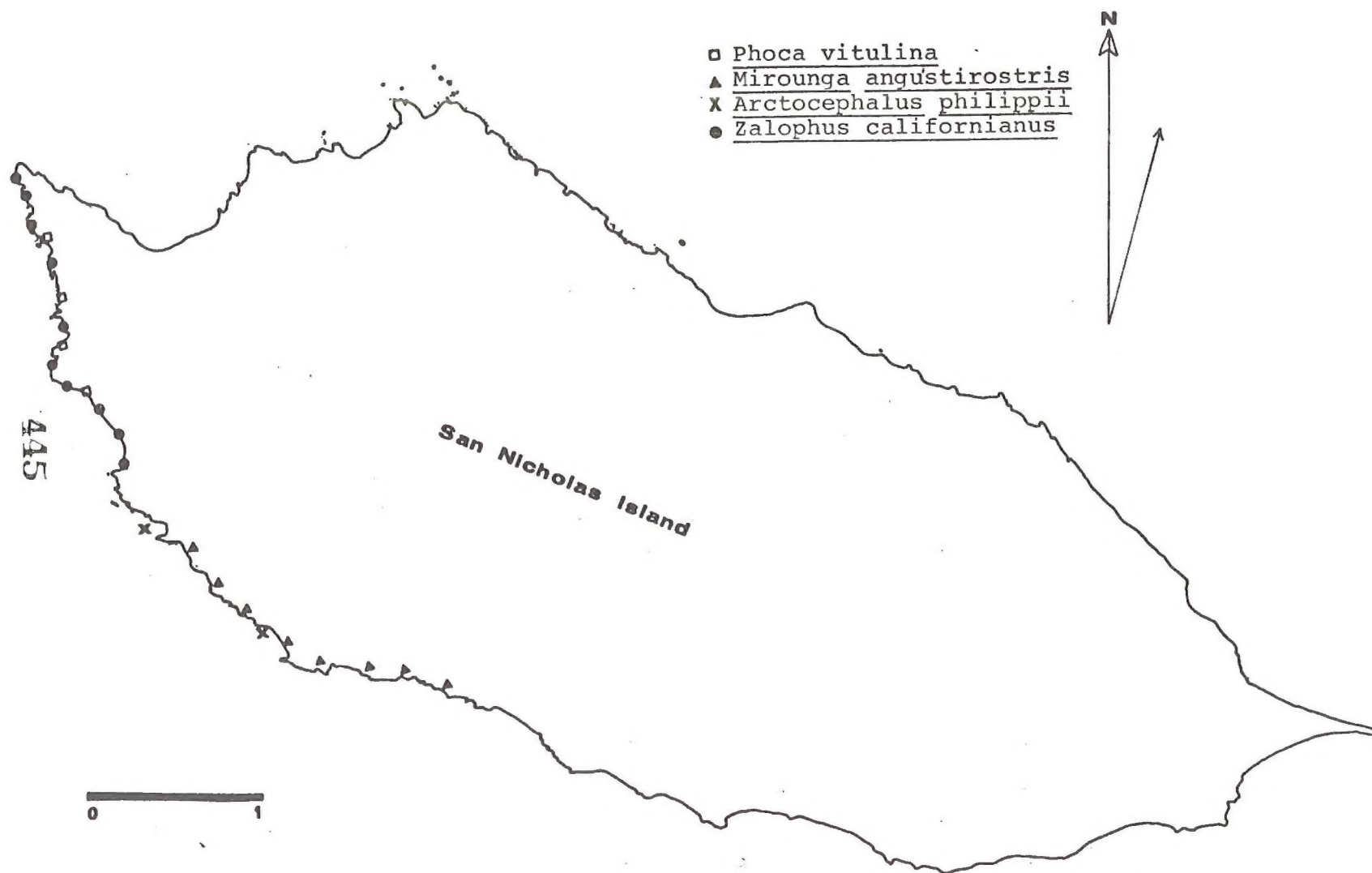


Figure II-67. Location of breeding and hauling out areas of pinnipeds on San Nicolas Island.

F. Important Marine Associated Habitats

1. Marshes, Bays and Estuaries

The majority of this section is taken from Ho (1974) of the Southern California Ocean Studies Consortium, but the bays and marshes of Southern California will first be summarized from the important coastal county publication by the California Department of Fish and Game (1973).

Santa Barbara County - The location of the important wetlands are shown on Figure II-68 and the acreages of marsh, mudflat, and open water are presented below.

Wetlands of Santa Barbara County Possessing Wildlife Habitats of Critical Importance

<u>Area</u>	<u>Type of Habitat in Acres</u>	
Goleta Slough	Marsh, 260	
El Estero (Carpinteria Marsh)	Marsh, 150; mudflat, 35; water, 15	
Santa Ynez River	Marsh, 110; water, 50	
Goleta Point Marsh	Marsh, 25; water, 35	
Santa Maria River	Marsh, 50; water, 15	
Devereaux Ranch Lagoon	Marsh, 15; water, 30	
<u>Type</u>	<u>Total Acres</u>	<u>Percent</u>
Marsh	610	77.2
Mudflat	35	4.4
Water	145	18.4

Goleta Slough, Carpinteria Marsh, and the mouth of the Santa Ynez River, comprising 80 percent of the county's wetlands are of major importance to the maintenance of numerous wildlife species.

These marshes appear to be relatively unaltered by human habitation.

SAN LUIS OBISPO CO.

SANTA BARBARA COUNTY

POPULATION

1970 264,100

1980 309,400

110 miles of coastline (islands excluded)

15% open to the public

Pt. Arguello

Pt. Conception

Gaviota

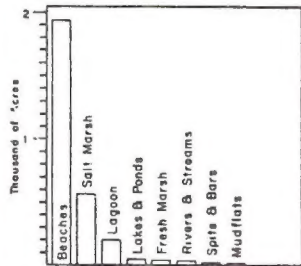
Goleta

Santa Barbara

Carpinteria
Rincon Pt.

VENTURA COUNTY

SANTA BARBARA COUNTY Wetland Habitat



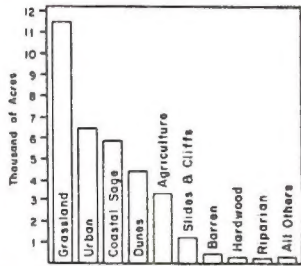
IMPORTANT BAYS, MARSHES AND STREAMS

1. Santa Ynez River
2. Goleta Slough
3. El Estero (Carpenteria Marsh)

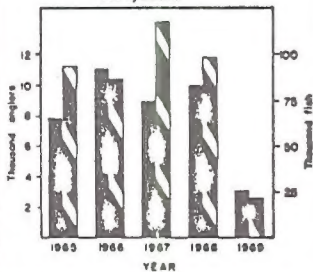
★ PARTYBOAT LANDINGS



SANTA BARBARA COUNTY Upland Habitat



SANTA BARBARA COUNTY Partyboats



SANTA BARBARA COUNTY Commercial

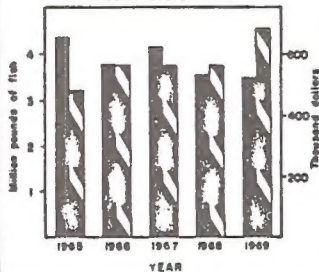


Figure II-68 From: Calif. Dept.
Fish and Game (1973).

Ventura County - The location of the important wetlands are shown on Figure II-69 and the acreages of marsh, mudflat and open water are presented below.

Wetlands of Ventura County Possessing Wildlife Habitats of Critical Importance

<u>Area</u>	<u>Type of Habitat in Acres</u>
Mugu Lagoon	Marsh, 1420; mudflat, 500; water, 250
Santa Clara River	Marsh, 40; water, 20
McGrath Lake	Marsh, 5; water, 15
Ventura River	Marsh, 5; water, 5

<u>Type</u>	<u>Total Acres</u>	<u>Percent</u>
Marsh	1,470	65
Mudflat	500	20
Water	290	15

The wetlands, located at Mugu Lagoon, are considered the most important in the county, comprising some 95 percent of the total. A fish and wildlife plan was prepared jointly by the Department of Fish and Game and the Bureau of Sport Fisheries and Wildlife for the military installation at Mugu Lagoon. The plan places emphasis on the value of the marsh and provides for its proper management.

The other county wetlands, while comprising only five percent of the total are extremely important due to the generally arid nature of the adjacent area.

Los Angeles County - The important wetlands listed are Bixby Slough, Ballona Creek and Colorado Lagoon (Figure II-70). These are all

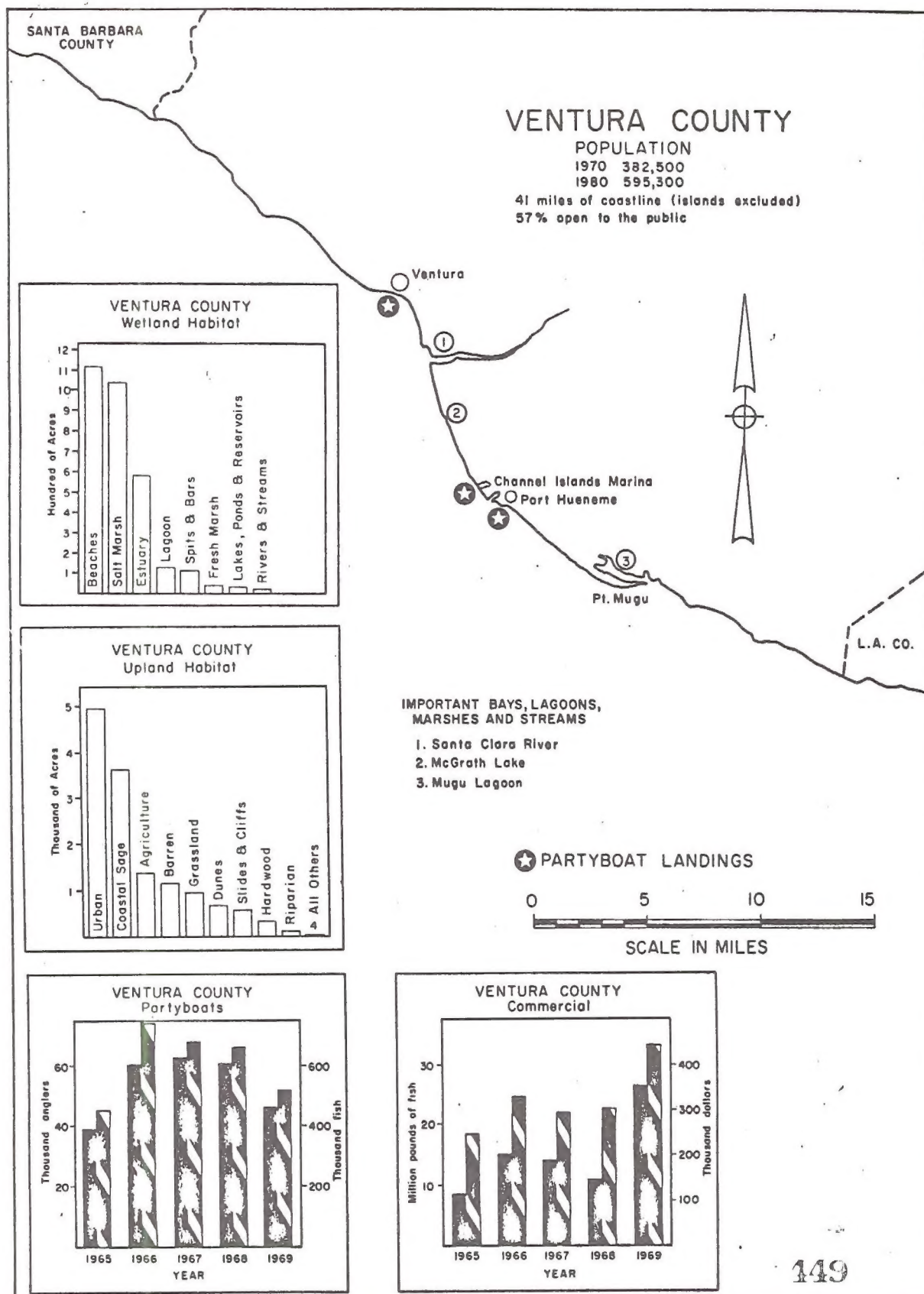


Figure II-69 From: Calif. Dept. of Fish and Game (1973).

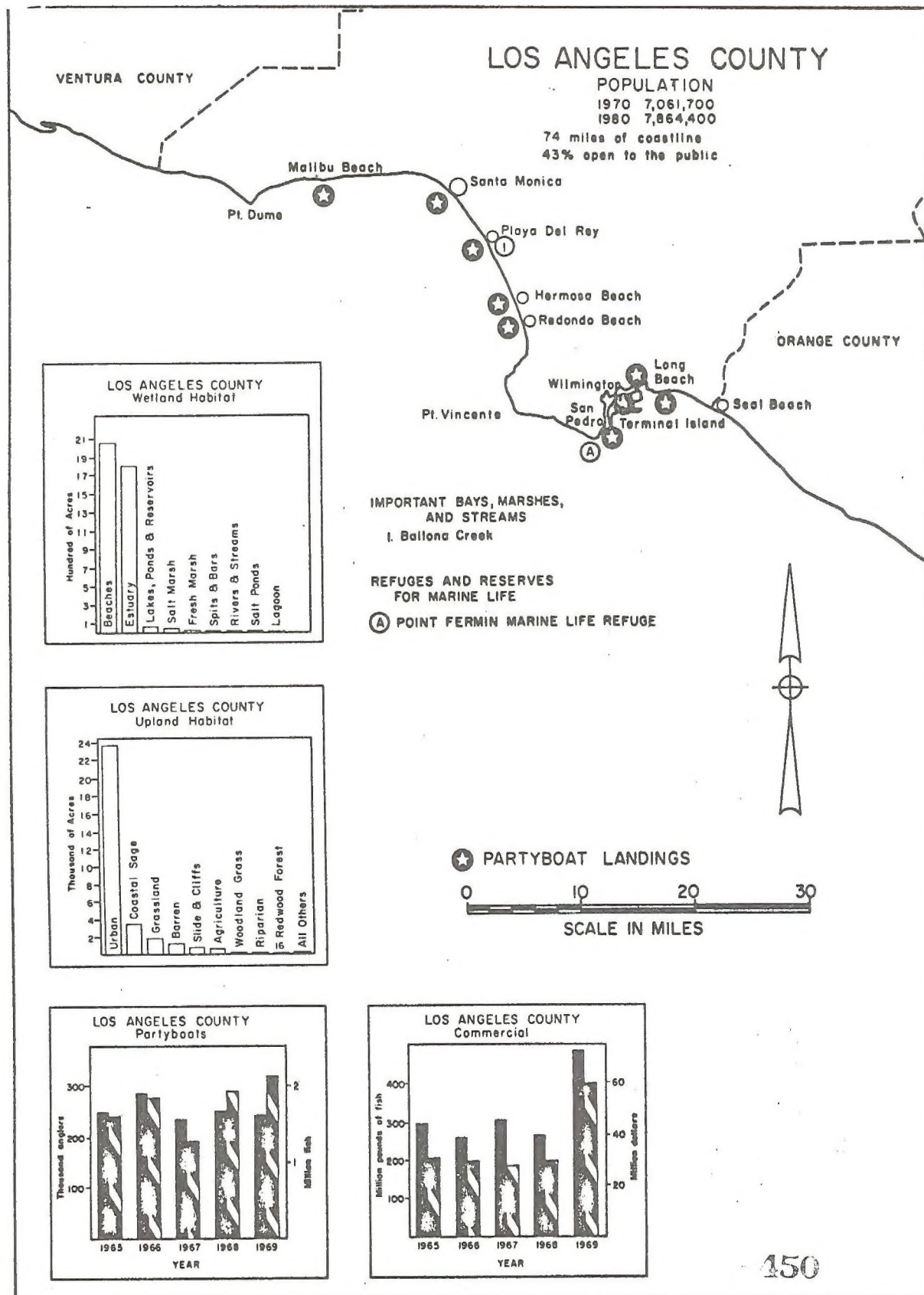


Figure 11-70 From: Calif. Dept. of Fish and Game (1973).

substantially altered by human habitation.

Orange County - The location of the important wetlands are shown on Figure II-71 and the acreages of the marsh, mudflat and open water are presented below.

Wetlands of Orange County Possessing Wildlife Habitats of Critical Importance

<u>Area</u>	<u>Type of Habitat in Acres</u>
Anaheim Bay	Marsh, 480; mudlat, 40; water, 370 <u>1/</u>
Bolsa Bay	(approx. 1,500 acres of degraded wetlands with potential for improvement.)
Upper Newport Bay	Marsh, 200; mudflat, 650; water, 500

<u>Type</u>	<u>Total Acres</u>	<u>Percent</u>
Marsh	680	30
Mudflat	690	31
Water	<u>870</u>	39
	2,240 <u>2/</u>	

The salt marshes, mudflats and protected waters of Anaheim Bay, Bolsa Bay and Upper Newport Bay are critical to the maintenance of shorebird and waterfowl populations in the county, the state and to the Pacific Flyway. These three areas contain almost all of the remaining wetland acreage in the county.

1/ Including harbor and tidal channels.

2/ Bolsa Bay not included in calculating total acres of wetlands.

Lower Newport Bay and Huntington Harbor are also excluded as these areas contain little or no marsh or mudflat habitat.

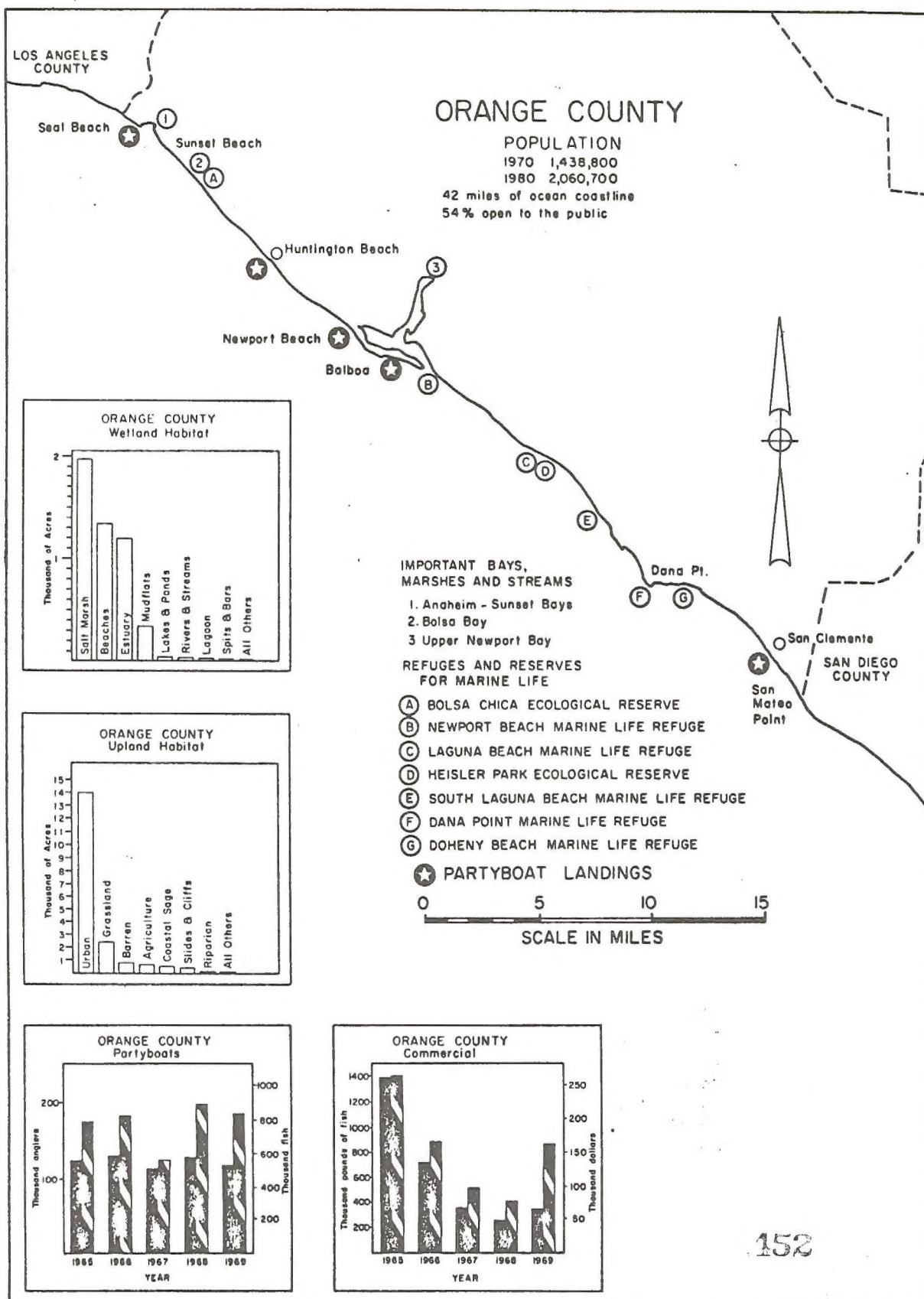


Figure II-71 From: Calif. Dept. of Fish and Game (1973)

Anaheim Bay contains about 520 acres of marsh (primarily cordgrass) and mudflats. Under Navy approval, the Department of Fish and Game, in cooperation with Fish and Wildlife Service, has prepared a Fish and Wildlife Plan for the Seal Beach Naval Weapons Station. The plan identifies the need for maintaining and enhancing the marsh and requires that no encroachments shall be made into the marsh without first exploring all alternatives.

Bolsa Bay has been drastically altered during the last century. Oil operations have required the building of a network of roads and paths throughout the marsh. Tidegates were installed in the main channel to the bay in the late 1800's. Though the flora and fauna of the bay have been modified, there remains a great potential for returning the bay's natural capacity to support fish and wildlife species. A restored marsh will provide habitat for the light-footed clapper rail and the least tern, both species in danger of extinction.

A permanent haven for these birds and hundreds of forms of marine life has been assured by the milestone land transaction between the state and Signal Properties, Inc. The agreement signed by Governor Reagan on March 15, 1973, gives the state fee title to 563 acres of land directly across the Pacific Coast Highway from Bolsa Chica State Beach in exchange for the state relinquishing its easement claims over some 526 acres of tide and submerged lands in the bay. The agreement was the result of more than a year and a half of negotiations between Signal Properties and a state interagency task force headed by the Department of Fish and Game.

The major portion of the area has been set aside as the Bolsa Chica

Ecological Reserve. The reserve will be developed in two phases:

(1) building of levees and flooding of marsh areas, and (2) construction of an opening to the sea to permit full tidal action into the area. The reestablishment of this saltwater marsh in the face of present trends is unprecedented anywhere in the world.

Upper Newport Bay is without a doubt the most outstanding estuarine ecosystem in Southern California. In a unique setting between vertical bluffs, the Upper Bay contains some 200 acres of salt marsh, 650 acres of mudflats, 500 acres of sheltered water and 260 acres of dunes and bluffs.

The values to wildlife have been documented in a Department of Fish and Game report, "Report on the Natural Resources of Upper Newport Bay and Recommendations Concerning the Bay's Development." A report, "The Marine Environment in Upper Newport and Sunset Bays, Orange County, California" was also published by the Department. Wildlife studies are continuing. A number of development proposals have been made spanning a period of 45 years. None has considered or included significant measures to maintain the Upper Bay's natural resources. The Department of Fish and Game and other agencies, groups and individuals concerned with maintaining the present ecological conditions of the Bay have sought to obtain consideration for natural resource protection in planning for the bay. An agreement has now been reached to turn Upper Newport Bay over to the state of California for establishment of an ecological reserve.

A part of the Irvine Marsh, recently purchased by the University of California at Irvine, is also a wetland area of importance to wild-

life in the coastal zone. It differs from Anaheim, Bolsa and Upper Newport Bays, by being a freshwater marsh area rather than salt marsh or tideland. An exchange of wildlife use occurs between the Irvine Marsh and Upper Newport Bay which actually results in each habitat type complimenting the other, resulting in overall resource benefits. In the midst of urban development, the Irvine Marsh contains a diversity of wildlife including deer, quail, doves, waterfowl, pheasants, and shorebirds, as well as a number of predatory and fur-bearing species.

San Diego County - The location of the important wetlands are shown on Figure II-72 and the acreages of marsh, mudflat and open water (when known) are presented below.

Wetlands of San Diego County Possessing Wildlife Habitats of Critical Importance

<u>Area</u>	<u>Type of Habitat in Acres</u>
San Diego Bay	Marsh, 360; mudflat, 600; water, 11,000; salt ponds, 1,400
Mission Bay	Marsh, 20; water, 2,340
Santa Margarita Lagoon	Wetlands (undifferentiated) 600
Tijuana River	Wetlands (undifferentiated) 400
Agua Hedionda Lagoon	Wetlands (undifferentiated but primarily water) but 300
San Diego River	Wetlands (undifferentiated) 250 ^{1/}
Batiquitos Lagoon	Wetlands (undifferentiated) 600 ^{2/}
San Elijo Lagoon	Wetlands (undifferentiated) 500

Total Wetlands (excluding the acreage of Bay waters in San Diego and Mission Bays and Agua Hedionda Lagoon 4,730

^{1/} Includes 150 acres of eelgrass.

^{2/} From "Coastal Lagoons of San Diego County."

Among the above areas, the 400-acre Tijuana River estuary remains the least disturbed by man. San Diego Bay, the San Diego River, Mission Bay, San Dieguito Lagoon and Agua Hedionda have been largely altered and have already lost much of their effectiveness as wildlife habitat.

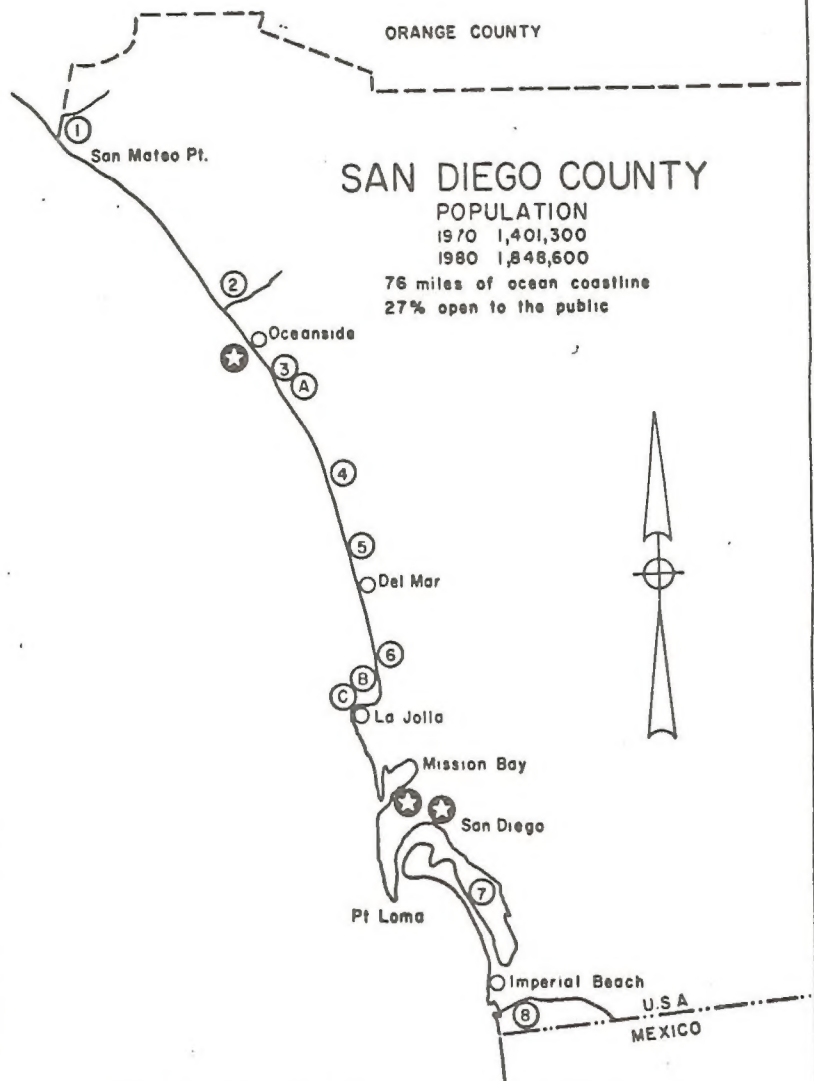
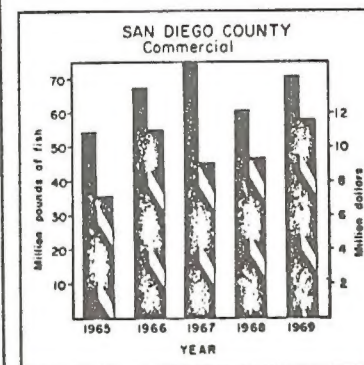
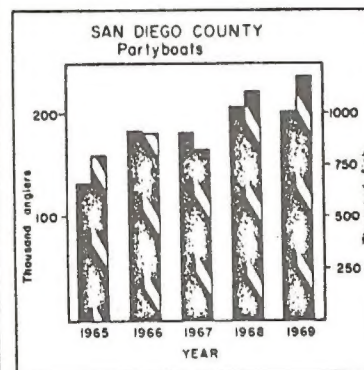
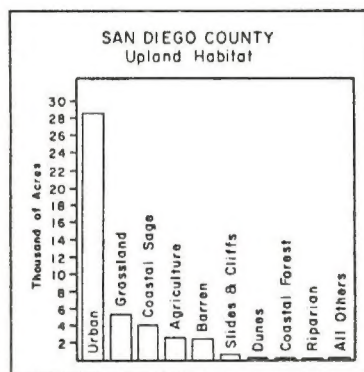
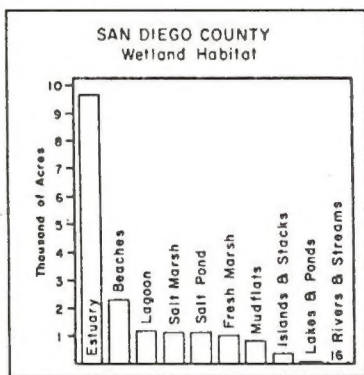


Figure II-72 From: Calif. Dept. of Fish and Game (1973).

However, the remaining marshes, mudflats, and salt ponds in South San Diego Bay continue to support large numbers of waterfowl, shore-birds, and other water-associated birds, and remain as the most heavily used coastal wetland in the county.

The remaining wetlands of San Diego County total approximately 4,730 acres, excluding the open water of San Diego Bay, Mission Bay, and Agua Hedionda Lagoon. Vast expanses of open waters, with small amounts of marsh and mudflat in relation to the open water area, are of less value to wildlife than the other wetlands of San Diego County with a higher percentage of marsh-mudflat habitats. However, these large expanses of shallow-water embayments are still valuable as fish nursery and spawning grounds.

The following is taken, except for minor changes, from Ju-Shey Ho (1974).

a. Introduction

California is notable in having coastal embayments developed in a smaller scale than its counterpart on the east coast, namely, New Jersey, Delaware, Maryland, Virginia, North Carolina, and South Carolina that stretch their total coastline almost in the same latitudinal range as California. This is particularly true on the coast of Southern California, where, due to arid climate and rather recent geological setting, the area is without a large river entering the sea. Consequently, the bays on the coast of Southern California are necessarily small, with the largest one, the San Diego Bay, being only 48.24 km² at mean low water (Anonymous, 1950). The absence of a coastal plain in Southern California has, furthermore, restricted the

development of salt marsh to small areas fringing sheltered bays and lagoons.

The bays considered here in this chapter are those tracts of water extending into the land and remaining connected to the sea only by a restricted, narrow entrance. The rivers in Southern California are seasonal streams and in their natural state are sealed off at their mouths by beach deposits during the dry seasons. Most of the so-called "bays" are actually abandoned mouths of the major streams, like San Pedro Bay, Upper Newport Bay, and Anaheim Bay, or separated from the sea by spits and tombolos, like Lower Newport Bay, Mission Bay, and San Diego Bay. All these characteristics are products of the strong surf of the exposed Pacific shore (Gosline, 1967). Some other loosely termed bays, like Santa Monica Bay and La Jolla Bay that are neither a landlocked embayment nor a derivative of an estuary with salt marsh development, are, accordingly, not considered in this chapter.

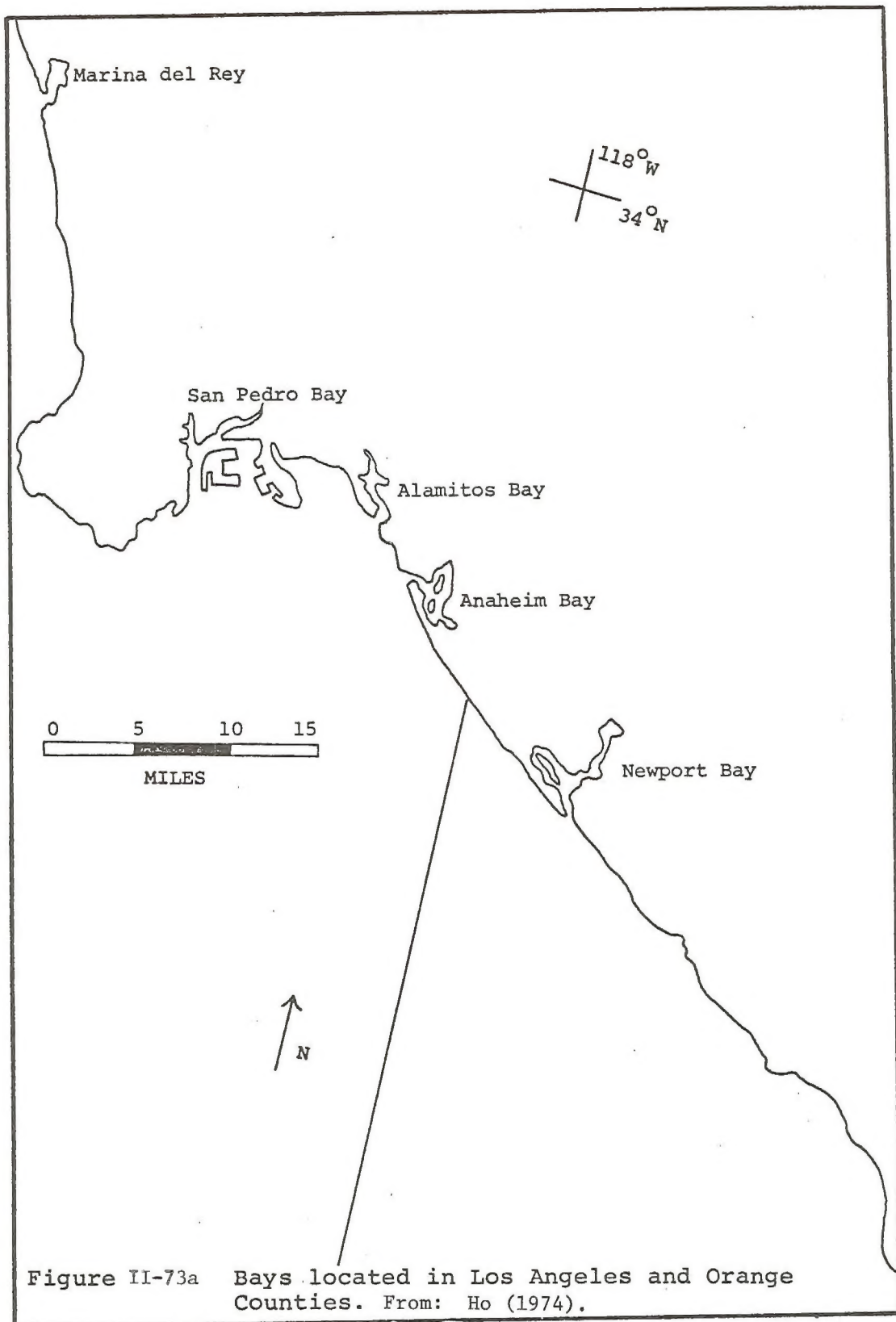
There are several small lagoons in San Diego County that are not periodically flushed by tide (Table F1-1). One of them, the Buena Vista Lagoon, has been completely separated from the sea for many years so that its salinity (3.0 - 6.5 ‰) is much lower than other embayments of the southland. Consequently, its fauna and flora are mixed with some freshwater types (Carpelan, 1964). All other embayments have their mean salinity about 32.5 ‰.

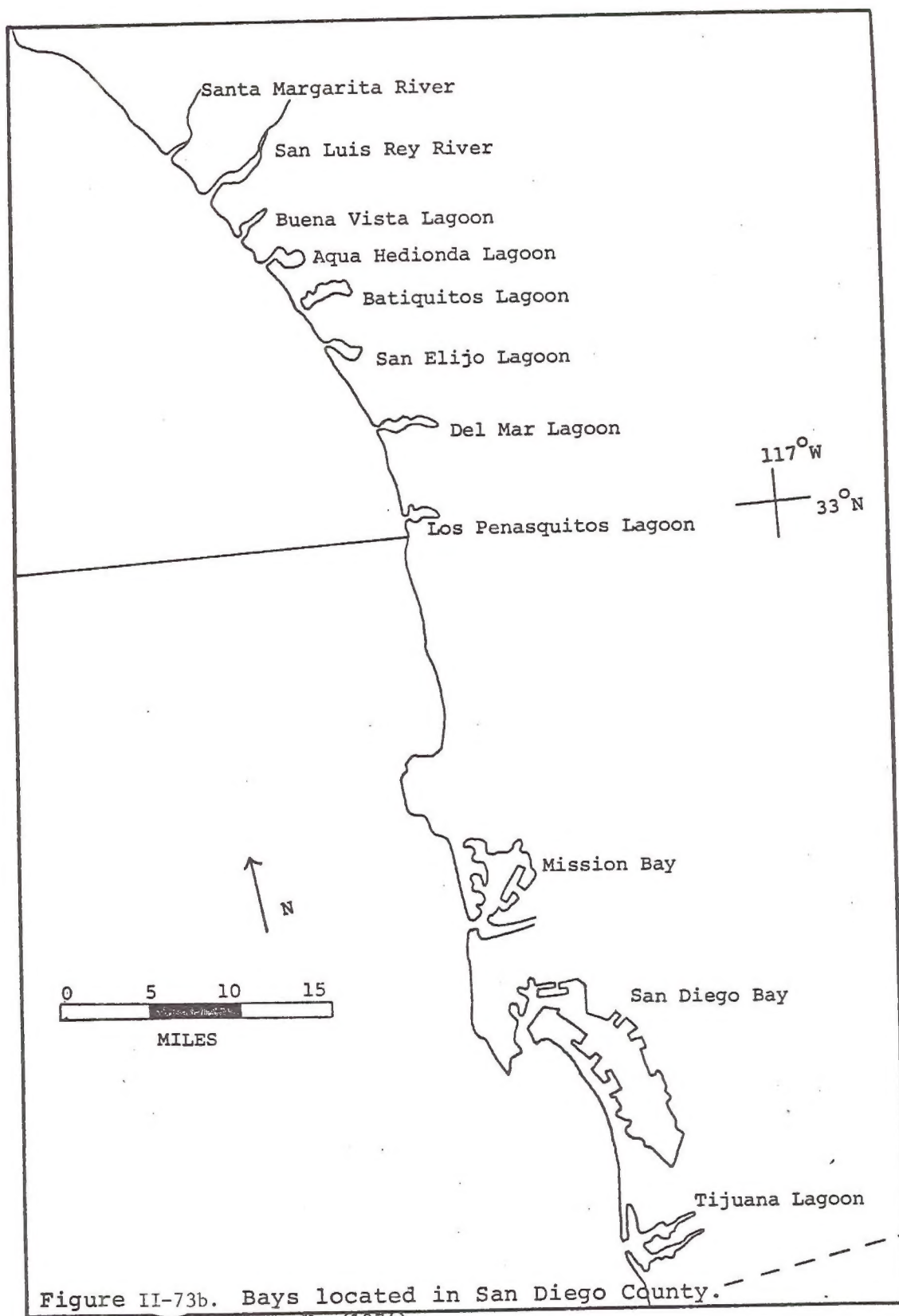
Salt marshes are tracts of land in the bays, estuaries, or lagoons that are covered with halophytes and subject to periodical flooding by

the tide. The striking feature of the marsh environment is the great variation in values of the parameters known to affect the occurrence and development of animal population. In the marsh of Mission Bay, for instance, Phleger & Bradshaw (1966) have recorded considerable diurnal and seasonal variation in pH, oxygen, water temperature, and salinity. These variances are related to tidal flushing, air temperature variation, sunlight duration, and marsh plant metabolism.

The great influx of population to the Southern California area, during and following World War II, has substantially altered the natural state of the southland; nearly all of the bays and lagoons have been modified by the activities of man, through construction of marinas and breakwaters, building roads and railroads, dredging of channels, diversion of rivers, and operation of waste disposals. Of the existing embayments (Table F1-1 in Appendix 10, F.1 and Figs. II-73 a&b), Anaheim Bay, Upper Newport Bay, and Tijuana Estuary are some major ones that still remain in a relatively unaltered condition. The California Coastal Zone Conservation Commission (1975) policy for estuaries and wetlands states that "all remaining coastal estuaries and wetlands and buffer areas necessary to protect wetlands and their wildlife and bird habitat values shall be preserved, enhanced, and where possible, restored." Further restoration of the relatively unaltered Upper Newport Bay, and restoration of Bolsa Chica is given high priority.

Estuaries and lagoons support animals recruited principally from the sea. Many neritic animal species use these areas as a nursery





From Ho (1974).

ground before migrating to the open sea (Vernberg & Vernberg, 1972). For example, shallow-water fishes such as the California halibut, the Pacific staghorn sculpin, the deepbody anchovy and the gray smoothhound are known to use Anaheim Bay as nursery habitats. Some permanent dwellers of Anaheim Bay that complete their life cycle in the bay are the top-smelt, the California killifish, the arrow goby and the diamond turbot. See Section ii. in the following pages for further details.

However, with a profound alteration of coastal wetlands in Southern California, to what extent they do still serve as a nursery and feeding ground for neritic animals has not been determined. It is known that with the fully developed commercial and residential marina-complex in Mission Bay, most, if not all, wildlife value has been destroyed (Speth, 1969). It goes without saying that when a substantial alteration of physiographic conditions is brought to a bay, the biota there will not be the same. Studies on the benthic animals of Anaheim Bay by Kawling & Reish (in press) have demonstrated that the density of benthic polychaetes showed striking differences between the dredged and the undredged areas.

With the ever increasing concern about the effects of waste disposal into the bays and lagoons, several surveys have been conducted in Southern California in order to assess the impacts on the biotic communities. These are: Anonymous (1950, 1952a, 1952b, 1972a, 1972b); Bradshaw (1968); Bybee (1969); California Department of Fish and Game (1951); Chapman (1963); Ford (1968); Hartman (1956); Mudie (1970);

Reish (1954, 1959, 1961a, 1961b, 1971b); and Turner & Strachan (1969). However, an extensive survey of the same bays and lagoons prior to active man-made modification is lacking in most cases. The works on the biota of Anaheim Bay by Anonymous (1972a) and Land & Hill (in press) and several surveys conducted in the Upper Newport Bay by Bane (1968); Barnard & Reish (1957); California Department of Fish and Game (1958); and Vogl (1966) are some existing reports that contain biological information of slightly altered bays in Southern California.

b. Vegetation and Zonation

The salt marshes of the Pacific coast of North America are very uniform in their type of vegetation (Chapman, 1960). Their floras are characteristic in containing relatively fewer species and their ecological succession is generally simpler than that found in other regions, such as in the East Coast and Gulf Coast. In Southern California this is particularly true; it perhaps reflects the small size and relatively recent establishment of the marshes (MacDonald, 1969).

The marsh plants are generally found in the upper intertidal areas of bays where currents are negligible and where there are no erosive waves. Most marsh plants are true flowering plants and frequently are called halophytes. Within a marsh, there is usually a pronounced zonation of plants, from plants which are covered by almost every tide to plants which may be covered by a tide only twice a year (McLusky, 1971).

In addition to halophytes, there are some other forms of marine plants that grow mainly in the water. These are the eelgrass, the algae, and the phytoplankton. The latter includes the red tide causative agent and many other unicellular plants, the diatoms and the dinoflagellates.

i. Vegetation

The species of plants and algae that occur in the bays and lagoons are found in the works by Reish (1968) for Alamitos Bay; Turner & Strachan (1969) for San Gabriel River Mouth; Baker (in press) and Shubin (in press) for Anaheim Bay; California Department of Fish and Game (1953), Stevenson & Emery (1958), Frey, Hein & Spruill (1970), and Vogl (1966) for Newport Bay; Carlberg (1970) and Mudie (in Anonymous, 1972b) for San Elijo Lagoon; and Purer (1942) for bays and lagoons of San Diego County. For the matter of convenience, plants and algae will be treated here in this section but other microscopical forms in Section C.i.

Plants. The primary colonist of salt marsh is commonly *Spartina foliosa*, which forms a belt at the level of mean high water. However, in the better drained areas, it is often replaced by the second dominant species, *Salicornia bigelovii*. This combined *Spartina-Salicornia* community occupies the greater portion of the marshes. Some other species of salt-marsh grasses are usually found in association with them. MacDonald (1969) has identified seven most frequent associates and discovered that the component of the associate floral groups were quite different between those which occur north and south

of Point Conception. The seven associate species in the two regions are (listed in order of decreasing abundance):

North of Pt. Conception:

Distichlis spicata
Triglochin maritima
Jaumea carnosa
Limonium commune
Frankenia grandiflora
Glaux maritima
Plantago marima

South of Pt. Conception:

Frankenia grandifolia
Suaeda californica
Monanthochloe littoralis
Triglochin maritima
Limonium commune
Jaumea caronosa
Distichlis spicata

A comparison of the above lists reveals that to the south of Point Conception, *Glaux maritima* and *Plantago maritima* were replaced by *Monanthochloe littoralis* and *Suaeda californica*; the most abundant associate species of the north, *Distichlis spicata*, became the least abundant in the south; and the fifth abundant species in the north, *Frankenia grandifolia*, rose to the most abundant species of the south. It should be mentioned that in his ecological study of the plants of the twelve marshlands of San Diego County, Purser (1942) found that *Atriplex watsonii* and *Batis maritima* are much more abundant than *Triglochin maritima* and *Jaumea caronosa*.

Algae. The most common and abundant algae is the tubular, filamentous form of green seaweed, *Enteromorpha crinita*. This species can withstand a wide range of salinity, temperature, and exposure to air and therefore is the most widely distributed algae occurring in bays and lagoons, particularly in quiet-water areas. Another factor of ubiquitous and abundant occurrence of *Enteromorpha* in San Diego County is,

assumed by Bradshaw & Mudie (1972), the discharge of nutrient-rich sewage effluent into the lagoons. On the mud banks of quieter water in Anaheim Bay, this species of green algae was reported to form a mat covering an area as large as 7 m² with 5 cm thickness (Shubin, in press).

Contrary to the salt-marsh grasses which are virtually eliminated from the substantially altered bay, the species of flat, sheet-like green algal genus, *Ulva*, are very common in the harbor and marina. They grow on rocks or attach to boat floats. It is particularly abundant in the spring and fall months. It is interesting to note that while *Ulva* spp. are abundant in the substantially modified Alamitos Bay (Reish, 1968), they are the least abundant species of all the algae surveyed in the rather unaltered Anaheim Bay (Shubin, in press).

The brown algae seems to be the least abundant of the three algal groups to occur in the bay or harbor (Table F1-2, App. 10, F.1.). In Purer's (1942) work on the flora of marshlands in San Diego County, not a single species of brown algae was reported. The three out of four species of brown algae reported from Upper Newport Bay (Frey, Hein, & Spruill, 1970) were listed as rare, with their occurrence being less than 4.9% of the flora. Of the sixteen species of brown algae listed in "The Marine Life of Southern California" (Reish, 1972), only three species: *Colpomenia sinuosa*, *Ectocarpus confervoides*, and *Hydroclathrus clathratus*, were mentioned to have been found in the bays or harbors. The poor occurrence of brown algae is another characteristic floral feature of the Southern California marshes and bays.

ii. Zonation

The zonation of plants in salt marshes is generally governed by the operation of the following environmental factors: tides, water table, soil structure, water movement, aerated layer, soil salinity, soil moisture, and biota (Chapman, 1964). However, it seems that tide is the single, most important factor in determining the distribution of salt marsh plants (McLusky, 1971). According to Ranwell (1972), the tidal factors of particular importance include: the mechanical disturbance (controls intensity and frequency of sedimentation and erosion), the vertical range (controls tidal flooding depths and the vertical extent of salt marsh), the form of tidal cycle (controls frequency and duration of submergence and emergence), and the water quality (controls the amount of light reaching submerged growths and the salinity).

Both Chapman (1960) and Macdonald (1969) have noted that above the level of MLHW (mean low high water; the intertidal zone that is exposed at least once every twenty-four hours) there are two major sub-environments in a marsh, namely, the low marsh and the high marsh (Fig.II-74. The former extends from the lower limit of salt marsh vegetation to the level of MHHW (mean high high water; with more than six hours of tidal submergence at each tide and less than fifteen days of continuous tidal emergence) and the latter includes the zones between the levels of MHHW and EHW (extreme high water; with less than six hours of tidal submergence and may be exposed in the air for several weeks or even months). Thus, the major difference between the

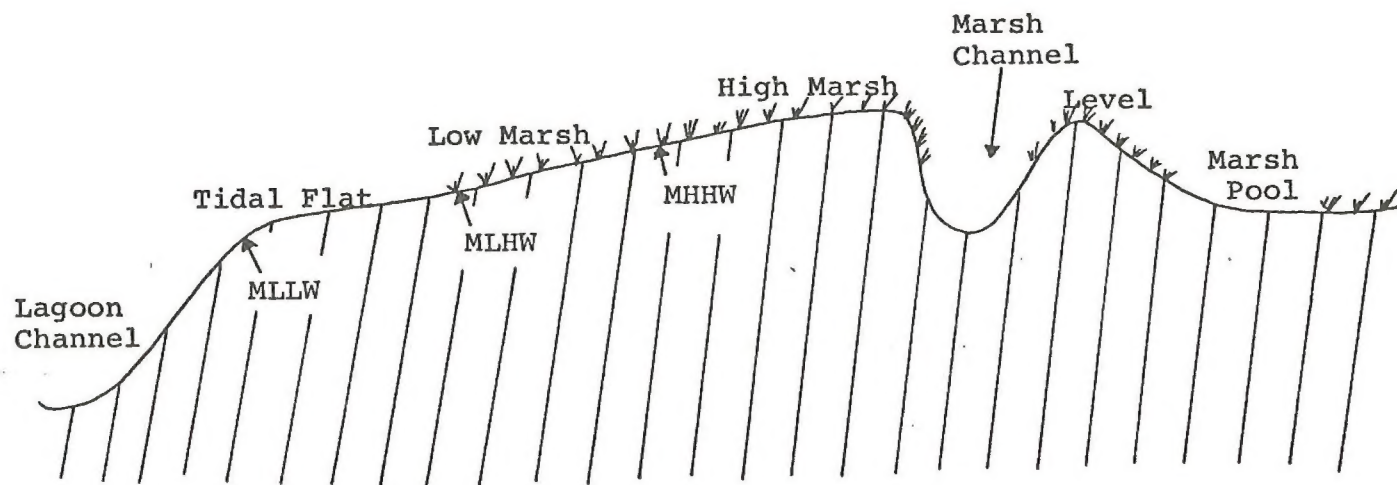


Figure II-74. Diagrammatic cross-section of tide levels and marsh zones in Mission Bay (after Phleger, 1970).

two sub-environments is the frequency and the duration of emergence and submergence. The area between MLHW and MLLW (mean low low water) is called tidal flat, where the land is submerged in water most of the time, except during extremely low tides.

The rate of supply of gaseous CO_2 for photosynthesis is severely limited during submergence, and different species may differ in their sensitivity to such limitation. Also, the lower regions of a salt marsh are covered by almost every tide, and the soil will often be water-logged; whereas plants in the upper regions are more rarely covered and the soil will have more opportunity for drainage. Therefore, a gradient in the sensitivity to CO_2 limitation and in the ability to live in water-logged soils may be the important factor in determining marsh plant zonation (McLusky, 1971).

The eelgrass, *Zostera marina*, is the most common angiosperm that grows on the permanently inundated marshlands. This is the lowest vegetative zone called Zosteretum. In a relatively unaltered bay, such as Anaheim Bay and Upper Newport Bay, the eelgrass is usually widespread. However, in a substantially altered bay, like Mission Bay and San Diego Bay, it is reduced to small patches, and in Alamitos Bay and San Pedro Bay, this species had disappeared because of dredging operation and other activities of man.

Above the Zosteretum, in Upper Newport Bay, Stevenson & Emery (1958) have identified five additional zones: Spartinetum, Salicornietum, Suaedetum, Monanthocloetum, and Distichlidetum. Each zone is named after the dominant species that occurred in it. They are: *Spartina foliosa* (cordgrass), *Salicornia bigelovii* (pickleweed),

Suaeda californica (seablite), *Monanthochloe littoralis* (shoregrass), and *Distichlis spicater* (saltgrass). However, in Anaheim Bay, Baker (in press) could identify only three additional zones: *Spartinetum*, *Batietum*/*Salicornietum*, and *Distichlidetum*.

It is noted that in San Elijo Lagoon (Anonymous, 1972b) and other periodically closed small lagoons in San Diego County, the typical salt marsh grasses, e.g., cordgrass, pickleweed, arrowgrass (*Triglochin maritima*), saltwort (*Batis maritima*) and eelgrass of the permanently submerged zones in Southern California are absent. This absence is apparently associated with the absence of continuous tidal flushing in these lagoons. Furthermore, due to the lack of frequent tidal action, the characteristic vertical zonation of salt marsh vegetation is weakly developed in San Elijo Lagoon. In Mission Bay, the *Spartina* community occupies about 60% of the marsh area. It occurs from about +1.0 to +1.5 m above the elevation of mean lower low water. At +1.5 to +1.8 m, an area of about 1.4% of the marsh, the flora is dominated by *Salicornia* and *Batis*. Above this level there is a community characterized by *Suaeda* and it takes up about 23% of the marsh area (Phleger, 1970).

c. Plankton Community

Although many studies and surveys have been made on the benthic life of bays and lagoons, only a few works were carried out on the planktonic life of the same water bodies. Furthermore, most of the works were made in the form of unpublished theses and reports and confined to three bays: Anaheim Bay (Felts, 1973; Howey, 1971; Slawson, 1972; Sowby, 1973), Mission Bay (Fairbanks, 1969; Snyder, 1965), and San Diego Bay (Damon, 1969; Sweeney & Clendenning,

1958). Certainly, this biotic community in the Southern California bays and lagoons deserves much more attention than it has received.

Estuary and bay, with its semi-enclosed nature, permit the maintenance of a plankton community that is at least native, if not strictly endemic (Riley, 1967). A survey of microbiota by Lackey (1967) reported 57 species of dinoflagellates and 41 species of ciliates from San Diego Bay, and 49 species of dinoflagellates and 23 species of ciliates from Mission Bay, but only 25 species of the former and 4 species of the latter were common in both bays, in spite of the entrances of the two bays being only about seven miles apart. The environmental factors controlling this specific feature of "native" population in estuarine plankton community are: degree of bay enclosure, shape of basin, temperature, salinity, water circulation, and cycling rate of elements. Riley explained that the maintenance of native population in an estuary and, conversely, the rate of invasion by coastal water forms will depend in part on the flushing rate and circulation pattern. From a dynamic standpoint, obviously, the rate of increase of the population must balance the rate of loss by flushing, predation, and all other natural causes in order for the population to maintain itself. In general, it is more of a problem for zooplankton than for phytoplankton.

Another characteristic feature of the plankton community in estuaries and bays is its large volume, but small number of species. As in Anaheim Bay, the annual mean plankton volume was 0.451 ml/m^3 , which is about two to six times of what has been previously reported for off-shore plankton volumes for the water off the Southern

California coast (Howey, 1971). However, of the twelve species of copepods that occurred in the bay, one species, *Acartia tonsa*, comprised an average of 89.6% of all copepods throughout the year.

1. Phytoplankton

The phytoplankton comprises all photosynthetic planktons. They are usually microscopic and composed of either a single cell or chains of loosely bound cells. Reproduction in phytoplankton is accomplished chiefly by binary fission in which each cell divides to produce two daughter cells. This population increase by geometric progression is of great ecological importance, since it enables a rapid response to favorable growing conditions and in certain circumstances may result in a bloom. An extensive bloom of *Gonyaulax polyhedra* occurred in Alamitos Bay in mid-September through mid-November, 1962, and was reported by Reish (1963) to be responsible for elimination of 26 various species of benthic polychaetes, crustaceans, and mollusks.

Composition of Phytoplankton. Diatoms and dinoflagellates are the two major groups of phytoplankton. A total of 26 genera of diatoms (Bacillariophyta) and 20 genera of dinoflagellates (Pyrrophyta) were reported by Fairbanks (1969) and Lackey & Clendenning (1965) from Mission Bay and San Diego Bay, respectively. However, only 10 genera of diatoms (*Thalassionema*, *Chaetoceros*, *Thalassiosira*, *Asterionella*, *Skeletonema*, *Coscinodiscus*, *Nitzschia*, *Navicula*, *Thalassiothrix*, and *Grammatophora*) and 5 genera of dinoflagellates (*Dinophysis*, *Prorocentrum*, *Peridinium*, *Ceratium*, and *Gonyaulax*) were recorded as major plankton, i.e., occur in numbers larger than 5% of the total phytoplankton

at least once a year. Lackey & Clendenning (1965) noticed that while populations of other phytoplankton were larger at the inner part of San Diego Bay than at the coastal areas, the opposite was true of the dinoflagellates.

In addition to diatoms and dinoflagellates, the phytoplankton of coastal embayments also consists of Volvocales, Chlorophyceae, Euglenophyceae, Cryptophyceae, and Chrysophyceae. The Volvocales are relatively common to inshore waters and are fairly well represented with 9 species occurring in San Diego Bay. Plankton Chlorococcales (Chlorophyceae) are not regarded as common in marine waters. However, in San Diego Bay, 26 blooms (500 cells/ml) were recorded from July 6 to August 9, 1959. The colorless Euglenophyceae are far more common and often more abundant in estuarine waters than the green ones, but the majority of them are benthos, and even those occurring in the plankton are also known from the benthic community. Of the 34 species of colorless Euglenophyceae in San Diego Bay, only nine species had ever been collected in water samples. *Eutreptia* is a wide spread and well recognized marine green euglenoid genus. In San Diego, it is represented by *E. lanowii*, which produced only one bloom in the summer of 1959. Cryptophyceae seems to be the most ubiquitous of all plankters. There are perhaps five genera (*Chilomonas*, *Chromonas*, *Cryptomonas*, *Cyathomonas*, and *Rhodomonas*) which appear to be important in the ecology of estuarine waters. All five genera are found in San Diego Bay and 12 blooms were recorded in 1959. Although 23 species of Chrysophyceae were identified from San Diego Bay, only five of them were responsible for the nine blooms observed in the summer of

1959 (Lackey, 1967; Lackey & Clendenning, 1965).

Factors Controlling Phytoplankton Population: The abundance of phytoplankton in the water is generally governed by the amounts of available PO_4 and NO_3 . A favorable N/P ratio is somewhere between 10:1 and 30:1 as far as abundance is concerned (Lackey, 1967). In Mission Bay, prior to the occurrence of red tide in May, 1968, the N/P ratio was 14.8:1 but dropped to 0.0038:1 when the bloom dissipated (Fairbanks, 1969).

Ryther and Dunstan (1971b) have demonstrated that nitrogen is the critical limiting factor of phytoplankton growth and eutrophication in coastal waters. They also found that about twice the amount of phosphate as could be used by the phytoplankton and other algae was normally present in the New York Bight. A similar conclusion was reached by Bradshaw and Mudie (1972) in their studies on some aspects of pollution in the bays and lagoons of San Diego County. They provided evidences that a dramatic inorganic nitrogen depletion may occur within a few thousand feet when the effluent enters a shallow, sluggish-moving stretch of lagoon. Apparently, the nitrogen was quickly absorbed by the phytoplankton and other plants. However, phosphate appears to remain in excess of phytoplankton demands.

The red tide of May, 1968, occurring in Mission Bay was closely watched by Fairbanks (1969). Initially, it was produced by the converging mechanism of cold, dense, nutrient-rich bottom water and a steep, shallow thermocline. At the peak of the bloom, cell counts of *Ceratium* reached 7.9×10^6 per liter and were accompanied by high silicate (26.1 mg-at/l) and phosphate (1.5 mg-at/l) concentration.

Nitrate was high at beginning of the bloom (8.9 mg-at/l) and was nearly exhausted by the end (0.01 mg-at/l). Dissipation of the bloom was attributed by him to be the combination of nitrate depletion, grazing by zooplankton (*Noctiluca*, tintinnids, and rotifers) and breaking up of the thermocline. The dinoflagellates associated with this red tide were: *Ceratium*, *Gonyaulax*, *Prorocentrum micans*, and *Peridinium*.

Fairbanks also found that the physical factors appeared to be of more importance to phytoplankton growth in surface waters, whereas nutrient concentration increased in importance with depth. High water temperature, high incident solar radiation, and high salinities appear to be detrimental to phytoplankton growth, especially when it is coupled with nutrient depletion. Tidal action was found to offset population size at the surface, where outgoing water causes the greatest changes, but at the 6-meter depth, the incoming rather than the outgoing tide is of most importance.

Seasonal Fluctuation of Phytoplankton Population. In Mission Bay, the annual phytoplankton cycle was characterized by a major bloom occurring in April and May. During the rest of the year, the population remained fairly constant with the smallest occurring in September in deeper water and January at surface water. However, when diatoms and dinoflagellates are examined separately, a different picture emerges. The diatom cycle appeared very similar to the total phytoplankton cycle, except with less pronounced April-May peaking (Fig.F1-11, App. 10, F.1). The dinoflagellate cycle, however, reached two peaks during the year, one in the fall and another greater one in the spring (Fig.F1-11, App. 10, F.1).

Sweeney and Clendenning (1958) reported that prior to August, 1963, when municipal and industrial wastes entered the inner harbor of San Diego Bay, the nanoplankton blooms occurred almost continuously in the harbor each summer. It is interesting to note that in Alamitos Bay, the bloom of dinoflagellates occurs in the months of fall rather than in the summer as in Mission Bay and San Diego Bay.

ii. Zooplankton

The zooplankton is composed of a great array of micro- and macroscopic animals ranging in size from a fraction of a millimeter to 30-50 mm. There are permanent plankton (holoplankton) and temporary plankton (meroplankton). The former are those animals completely adapted to a pelagic mode of existence, like copepods, mysids, and chaetognaths, and the latter are the transitory floating stages such as eggs, larvae, and juveniles of the benthos and nekton. The meroplankton are often seasonal in occurrence and abundance.

Although zooplankton are often assumed to be the primary consumer in pelagic food webs, serving to transfer energy from phytoplankton to secondary consumers, they are, however, relatively inefficient in the food chains of the shallow estuaries and bays. They usually graze on only 2-9% of the available phytoplankton production (Williams, Burdick & Thomas, 1968). A number of factors have been suggested to explain this situation (Riley, 1967): a) inefficient feeder occurred as the dominant species of zooplankton, b) unmatched seasonal cycles of phyto- and zooplankton, c) benthos competing directly with zooplankton for food, and d) predation by other animals on zooplankton.

Composition of Zooplankton. As in the case of phytoplankton, the zooplankton of Mission Bay were also divided into major and minor contributors to the total population. The major constituents of the zooplankton include: *Noctiluca* (holozoic dinoflagellates), *Heliocladus* (radiolarians), tintinnids (ciliates), mollusk larvae, polychaete larvae, barnacle larvae, cladocerans, and copepods (Fairbanks, 1969). Copepods are the major constituents of all the plankton at all depths throughout the year in Mission Bay.

Although *Noctiluca* is one of the major constituents of zooplankton in Mission Bay, it was not recorded at all by Lackey and Clendenning (1965) from San Diego Bay, where over one hundred species of dinoflagellates and more than thirty species of colorless zooflagellates are known to occur.

The copepod is also the major constituent of zooplankton in Anaheim Bay. It consists of twelve species, but only five of them are major contributors, i.e., *Acartia tonsa*, *Paracalanus parvus*, *Labidocera trispinosa*, *Oncea minuta*, and *Corycaeus* sp. (Howey, 1971). Other frequently encountered holoplankton include cladocerans, ostracods, mysids, and pycnogonids. Some typical off-shore holoplankton, such as hydromedusa, *Pleurobrachia* (ctenophore), *Tomopteris* (polychaete), *Sagitta* (chaetognath), *Oikopleura* (Larvacea), and thaliacean occur in the bay only on a limited basis. Meroplankton of crustacean larvae, fish larvae, and eggs and larvae of unidentified vertebrates and invertebrates are quite common in the bay.

Of the 12 families of fish larvae recorded by Snyder (1965) from Mission Bay, only five species of major contributors that

constitute 94.7% of the total fish larvae collected. They are (in order of decreasing abundance): *Clevelandia ios*, *Engraulis mordax*, *Atherinopsis californiensis*, sciaenids (possibly *Cynoscion* sp.), and *Hyposoblennius* sp. Slawson's (1972) study on the cladocerans of Anaheim Bay showed an occurrence of only five species, with two of them, *Podon polyphenoides* and *Evadne nordani*, accounting for 90% of the total cladoceran numbers. These are some examples of the characteristic feature of estuarine plankton with large volume dominated by small number of species.

Factors Controlling Zooplankton Population. Among the various environmental factors, temperature seems to be the most important one in controlling the seasonal abundance of zooplankton in Anaheim Bay (Slawson, 1972; Sowby, 1973). Since the meroplankton derive mainly from the benthos, its presence will be controlled initially by the temperature requirements for adult spawning. Furthermore, the duration of the planktonic larval stage is also influenced by temperature. Generally, within the favorable range, the lower the temperature, the slower is the larval growth which thus prolongs the planktonic stage. However, for a meroplankton contributor like the arrow goby (*Clevelandia ios*) in Mission Bay that has a protracted spawning season, temperature seems to be not a significant factor. The coefficient of correlation between temperature and number of larval goby computed by Snyder (1965) was only 0.11. On the other hand, like the greatest holoplankton contributor to the plankton community, *Acartia tonsa*, an eurythermal and euryhaline species, temperature is not a limiting factor of its presence and abundance in the bay.

Distribution of zooplankton in the bay seems to be controlled by the combination of tidal current and the degree of constriction of the bay opening. While the scarcity of offshore holoplankton in the bay was attributed to the constriction and limited circulation of water between the off-shore area and the inner part of Anaheim Bay (Felts, 1973; Howey, 1971; Slawson, 1972), the tidal current alone accounted for the different patterns of meroplankton distribution in the same bay (Sowby, 1973). For instance, the larvae of pistol shrimp, *Crangon nigrimaculata*, are hatched off-shore, but occur throughout Anaheim Bay and the mudshrimp, *Callinassa* sp., an inhabitant of the bay, has its larval stages recorded off-shore.

Although salinity is generally one of the major environmental factors in controlling the kinds, the abundance, and the distribution of zooplankton in the bays and estuaries, it is, however, not the case in Southern California, where low rainfall and less freshwater runoff minimize the fluctuation of salinity. Southern California coastal waters have an annual mean salinity of 34 ‰ and in the bay it is about 32.5 ‰. Therefore, practically all off-shore forms can survive in the bays of Southern California.

Food availability appears to be not a controlling factor of zooplankton population size and appearance. Most of the zooplankton are herbivores that feed on phytoplankton. It has been estimated that the estuarine zooplankton consume, at most, some 50-60% of the phytoplankton production and the remainder goes mainly to benthic fauna and flora. Fairbanks' (1969) study on the Mission Bay plankton showed that the increase in the standing crop of zooplankton did not always

correlate with the decrease in that of the phytoplankton. Although decapod larvae are carnivorous meroplankton, their food items (copepods and cladocerans) occur and constitute throughout the year over 50% of the total plankton volume in Anaheim Bay (Sowby, 1973). Therefore, even the carnivorous plankton are not controlled by food for their abundance and appearance in the bay.

Reaction to light with diurnal migration is prevalent in the off-shore plankton. Although Snyder (1965) has collected in Mission Bay four times as many fish larvae in the night sampling than in the daylight, he did not attribute this result to the effect of light alone but accumulative effects of light and tidal exchange.

Seasonal Fluctuation of Zooplankton Population. On the east coast of North America and the European coast, the most common and significant difference between estuarine and oceanic zooplankton is the relatively large summer population in the estuary. It is the result of a high level of primary production in the estuary and reflects the addition of numerous larvae of benthic invertebrates to the total plankton volume (Riley, 1967). In Anaheim Bay and Mission Bay, however, the peak of zooplankton population occurs mainly in the winter and spring months (Fig. F1-12, App. 10, F.1). This seasonal difference in the peak plankton volume from the east coast is attributable to the early appearance of larvae of the benthic invertebrates along the California coast (Painter, 1966; Sowby, 1973). However, if the contribution of meroplankton to the total plankton community is considered according to their phylogenetic groups, a different picture emerges. The mollusk and barnacle larvae have peak appearances in

the summer but the polychaete larvae were found as a major constituent only in November (Fairbanks, 1969).

d. Benthic Community

The benthic community includes all the organisms which live on or in the bottom of a given water body. The fouling organisms that commonly occur in the harbor and marina are also included in this community. Since the flora of this community has been treated above in section b.i., this section is devoted entirely to the remainder, the fauna.

Bacteria are both benthic and planktonic and have as much influence on the distribution of other plants and animals in the marsh and bay as has temperature, salinity, nutrient concentration, and other physical and chemical parameters (Hedgpeth, 1957). They are important, on the one hand, in decomposing dead organic matter for supplying necessities of plant growth, like nitrates, phosphates, carbon dioxide, etc., and, on the other hand, in serving as food for the various bottom dwelling animals. Zobell and Felthm (1942) have noted that bacteria are much richer in the water and mud of a bay than those of the open sea. In Mission Bay, the aerobic bacteria are not only abundant at the surface, but also occur in greater numbers than anaerobic bacteria to a depth of about 60 cm, where it is well below the depth of free oxygen. Some infaunal ciliates (*Euplotes*) and nematodes living in anaerobic bottom sediments may feed on these associated bacteria.

Information on the benthos of bays and harbors in Southern California are found in the works by Johnson (1971) and Reish (1965)

for Marina del Rey; Anonymous (1952a), Barnard (1950, 1952, 1953, 1954, 1955, 1958), Barnard & Reish (1957, 1960), Hartman (1956), Horvath & Menzies (1951), Mensies (1951a, 1951b, 1952, 1957), Mohr (1953), and Reish (1954, 1955, 1959, 1961b, 1971a, 1971b) for Los Angeles-Long Beach Harbor; Eckelbarger & Reish (1972), Reish (1961a, 1963, 1964a, 1964b, 1968), and Reish & Winter (1954) for Alamitos Bay; Reish (1956) and Turner & Strachan (1969) for the mouth of the San Gabriel River; Lane & Hill (in press) for Anaheim Bay; Bane (1968), Barnard & Reish (1959), California Department of Fish and Game (1953), Dawson (1963), Frey, Hein & Spruill (1970), MacGinitie (1939), Menzies (1950), and Scheer (1945) for Newport Bay; Carlberg (1970) for San Elijo Lagoon, Bradshaw (1968) and Carpelan (1961) for Los Penasquitos Lagoon; Bradshaw (1968), Chapman (1963), Macdonald (1969a, 1969b), Niesen (1969), Phleger (1970), and Phleger & Bradshaw (1966) for Mission Bay; California Department of Fish and Game (1951), Johnson & Menzies (1956), Juday (1907), McClendon (1909), Menzies (1954), Menzies & Widrig (1955), and Lackey & Clendenning (1965) for San Diego Bay; and Bybee (1969) for Tijuana River Estuary.

The benthic animals creep, crawl, burrow, or attach to the bottom. Those species living upon or associated with rocks, stones, shells, piling and vegetation are called epifauna, whereas those living buried or digging in a substratum represent the infauna. A third group, loosely termed demersal animals, including bottom dwelling fishes and motile invertebrates, is intimately related to the animals of the benthos. While the number of infauna species seems to be roughly the same in arctic as in temperate or tropical seas, the number of epifauna

species increases toward the tropics (Thorson, 1957). It is of interest and important to note that in the coastal embayments of Southern California, the degree of physiographic modification can be measured with the relative abundance of the epifauna, for construction of harbor, marina, and jetties encourages the encroachment of epifaunal species upon the bay.

The distribution and abundance of benthos in a bay or harbor is determined to a large extent by the textural quality of the substratum. Differences in bottom texture lead to a segregation of animal feeding types (Gosner, 1971). Coarse sediments composed mainly of sand (0.05-2 mm) or sand with gravel (>2 mm), that is common in estuaries usually shelter suspension feeders. Silt (0.002-0.05 mm) and clay (<0.002 mm) particles settle out in quiet waters, producing mud or soft substrate. The attachment of organic debris to these fine particles is a major factor in the distribution of the detritus feeders. Excess of organic matter, however, may lead to a deficiency of oxygen and a reduction in the total fauna. Such conditions are often indicated by the blackening of subsurface layers, which is taken to indicate the presence of anaerobic bacteria.

The benthic community, particularly the infauna, generally reflects the condition of the environment not only at the time of sampling but also prior to sampling. Accordingly, Reish (1961b) proposed the importance of the knowledge of benthic animal composition in serving as an indicator of changes in the environmental conditions and also as a means of monitoring the health of the environment.

Another method of classifying the bottom community is by their

body size. The animals which pass through a 0.1 mm screen are called microbenthos (microfauna) and those which are retained but will pass through a 1.0 mm-mesh sieve are called meiobenthos (meiofauna). Macrobenthos (macrofauna) are animals that are too large to pass through a 1.0 mm screen. For the matter of convenience, the existing knowledge of the benthic fauna of bays and harbors is given in the following according to these three different groups.

i. Microbenthos

The microbenthos includes bacteria, blue-green algae, and most of the Protozoa. Because of their smallness and required special methods of collecting and study, this is the group of the benthic community that has in the past received the least attention. However, their importance to the coastal ecology is by no means the least.

Ciliates are fairly abundant in the bay. Lackey (1967) reported 41 species from San Diego Bay and 23 species from Mission Bay. Some of them, especially tintinnids, occurred in the plankton, but the majority of them were more frequently encountered as benthos (Lackey & Clendenning, 1965). Benthic ciliates are important in the ecology of coastal embayments. Almost all of them are holozoic that eat bacteria voraciously, though a few eat small algal cells or other protozoans. Their consumption of bacteria tends to keep the bacteria in the growth phase and, in turn, they become a ready food for larger animals, such as the copepods.

Although the great majority of dinoflagellates are planktonic, there are four species (*Exuviaella* sp., *Gymnodinium stigmata*,

Thecadinium kofoidi, and *Thecadinium* sp.,) reported by Lackey & Clendenning (1965) to occur in San Diego Bay exclusively as benthos.

The benthic foraminifera of marsh areas in Mission Bay have been extensively studied by Bradshaw (1968), Phleger (1970), and Phleger & Bradshaw (1966). About 25 species are found in Mission Bay marshes. They are separated into two distinguishable fauna, a high marsh and a low marsh (Table Fl-3, App. 10, F.1). The former assemblage consists of purely agglutinated ones (with sand or silt test) and the latter, several calcareous species. This faunal zonation of high and low marsh forms is, as in the case of vegetal zonation, related to elevation, amounts of tidal flooding, and exposure (Phleger, 1970). The standing crops of these foraminifera vary greatly, but generally, the largest stocks are found in the high marsh and the smallest, on the tidal flats (see Fig. II-74).

ii. Meiobenthos

As defined by Hulings and Gray (1971), the term "meiofauna" generally is used to refer to animals that can pass a 1.0 mm screen. This is a relatively new definition as older literature considered the meiobenthos to be smaller. In his exhaustive treatment of estuarine benthos, Carriker (1967), reported meiobenthos to be those invertebrates which are retained by roughly a 0.1 to 0.5 mm opening mesh. This difference is important to remember because the groups of invertebrates reported to comprise the majority of the meiobenthos were of smaller size than those in newest definition. On the basis of the presence or absence of the resistance of the integument to mechanical damage, the meiofauna is further

divided into "soft" and "hard" fauna. The former includes Ciliata, Cnidaria, Turbellaria, Gnathostomulida, Nemertina, Gastrotricha, Archiannelida, Polychaeta, Oligochaeta, Mollusca, and Echinodermata; and the latter, Foraminifera, Kinorhyncha, Priapulida, Nematoda, Bryozoa, Brachiopoda, Mystacocarida, Ostracoda, Copepoda, Palpigradida, Halacaridae, Tardigrada, and Tunicata. Some groups, like Cnidaria, Mollusca, Bryozoa, Brachiopoda, Echinodermata, and Tunicata are rather rare in the meiofauna. Nematoda and Copepoda are the most abundant and are frequently encountered meiobenthos; they together comprise 89 to 99% of the total meiofauna (Wieser, 1960).

Animals of the meiobenthos all tend to be in the size of 0.5-1.0 mm, and are often very elongated, to enable them to fit in between sand and mud particles. Since they largely live between and on sediment particles, they are sometimes called "interstitial" fauna, especially those from sandy environments.

Carriker (1967) pointed out that the meiobenthos could be separated into three ecological groups according to their various degrees of affinity with the sediment particle size, i.e., sand-dwelling species, fine deposit-dwelling species, and eurytopic species. Thus, the meiobenthos at any point in the bay is determined by the degree of mixing of sediment types, to which it is quite sensitive, and consists of a subtle graded series of faunal assemblages. Most meiobenthos feed on the epigrowth of sand grains or on the fine deposits, which further affects their distribution.

The nematodes generally occur in greatest number in the top 5 cm of sediment. Large populations of nematodes have been found living in

the interstitial water within mud and sand in the bays of Southern California (Frey, Hein & Spruill, 1970; Reish, 1968, 1972), but in all cases not even species identifications were given. Therefore, this is perhaps the most abundant group of animals of all benthos but, ironically, is also the least studied. The reasons for this disparity are manifold and complex, but the most important single reason is probably the difficult nature of marine nematode systematics (Hope, 1971).

Although some pelagic species of ostracods were recorded in plankton samples in San Diego Bay (Juday, 1907), the great majority of them live on or near the bottom, or in some cases in the upper few millimeters of the bottom sediments, through which they root and burrow after food. The nature of the bottom sediments is, therefore, of extreme importance in determining the species of ostracod. As in the case of the nematodes, this is another little known group of meio-benthos in the Southern California bays, yet their abundance in the bay is not negligible. Klingbeil (1972) has reported that the top-smelt, *Atherinops affinis*, was the most frequently captured fish in Anaheim Bay, and in the larger specimens, ostracods were the most frequent organism seen in the gut contents, occurring in more than 80%.

According to Warne (1971), *Xestoleberis aurantia* is the only ostracod abundant on the marsh and present in all environments below the marsh except the large sandy channels. It is the most common ostracod that occurred in the samples from Upper Newport Bay and Mugu Lagoon. Warne also reported that several species of *Cyprideis*, *Loxocomcha*, *Bradleya* and *Cythereis*, that are known from Todos Santos

Bay, Baja California, were found or were likely to be found in Mugu Lagoon. If this is the case, the same species may as well be found in the bays and lagoons of the other areas of Southern California.

It is important to mention here that an as yet undescribed cephalocarid crustacean was found in Anaheim Bay. So far, only one intact specimen was collected from the intertidal mud flats near Hog Island in the bay (Lane, in press). From the facts that several subsequent attempts to find this crustacean from the bay were unsuccessful and only a few specimens had ever been found in the stomach contents of arrow gobies in the bay, this cephalocaridean could be one of the rarest meiobenthos living in Anaheim Bay. The importance of protecting this crustacean from elimination in Southern California bays is not only because of its rareness but also due to its significance in the understanding of the biology of Crustacea. The cephalocarids are the most primitive living crustacean in the world and up to the present only 3 genera and 8 species are known in existence. A systematic study of this new Cephalocarida is currently in progress.

iii. Macrobenthos

Animals considered as macrobenthos include both invertebrates and vertebrates. Generally, because of their conspicuousness, this group is better known than the micro- or meiobenthos. In most works on the faunal surveys of bays and harbors, the species recorded and identified are mainly of this group. However, small macrobenthos, such as turbellarians, nemerteans, and certain crustaceans, are still not very well known.

The invertebrate macrobenthos in the bay can be either a suspension feeder, detritus feeder, or predator, but the vertebrates, mainly benthic fishes, are largely carnivores. The feeding habits of macrobenthos are known to be closely related to the sediment types (Carriker, 1967). The detritus feeders predominate in areas of slow currents in the bay that have silt deposition; the suspension (filter) feeders exceeded detritus feeders in all areas of the bay where the grain size is of fine sand (0.1-0.25 mm); and the largest standing stock of predators occur in high energy environments where the sediment size surpassed fine sand and the contents of clay and organic matter are generally low.

Invertebrates. Due to their importance as indicators of bottom conditions (Reish, 1964a), polychaetous annelids are the most studied animals of all the macrobenthos in some Southern California bays and harbors. Amphipods and mollusks are perhaps the only other groups that have in the past received certain attention. However, almost all of the previous surveys and studies were conducted on the macrobenthos of bays and harbors in Los Angeles and Orange Counties and very little was done on those in San Diego County (Table F1-4, App. 10, F.1).

According to Kawling and Reish (in press), the polychaete diversity is about equal in the four studied embayments of Southern California, i.e., Los Angeles-Long Beach Harbors, Alamitos Bay, Anaheim Bay-Huntington Harbour, and Newport Bay. Since the number of species found in a study area depends to a large extent on the number of stations and the number of visits to each station, the figure given in Table F1-5 (App. 10, F.1) for San Diego Bay cannot be used for this comparison of species diversity.

Thirteen species and two genera of polychaetes are commonly encountered in the bays (Table F1-5, App. 10, F.1). These taxa were so prevalent that one could probably describe the benthos of any Southern California embayment as being characterized by several or all of them. However, many less frequently occurring species were collected, from only one area, especially from the upper reaches of each embayment (Reish in Barnard & Reish, 1959). Kawling and Reish have concluded further that all the prevalent species of polychaetes were distinctly more abundant in one area or the other. The single most common polychaete species in Southern California's bays and harbors is probably *Capitita ambisita*, which was found in all studies and usually in substantial numbers. Although an extensive survey on the polychaete fauna of San Diego Bay is yet to be made, the existing record (California Department of Fish and Game, 1951) shows that there is no occurrence of *Capitita ambisita* and *Lumbrineris erecta* replaces the status of *Lumbrineris minima*.

A cosmopolitan species of polychaete, *Capitella capitata*, was discovered by Reish (1955) to be an indicator of pollution in the Los Angeles-Long Beach Harbors (Table F1-7, App. 10, F.1). Barnard (1958) also pointed out that three species of cosmopolitan amphipods, *Corophium acherusicum*, *C. insidiosum*, and *Podocerus brasiliensis*, were also indicators of pollution in the same harbor. These species can thrive in many parts of the harbor where other species of polychaetes and amphipods do not live.

The most common amphipods occurring in Newport Bay are (Barnard & Reish, 1957): *Amphideutopus oculatus*, *Acuminodeutopus heterurupus*, *Rudilemboides stenopropodus*, and *Paraphoxus* sp. Although none of them is endemic to Newport Bay, a certain degree of "nativeness" is observed. They are not found in any abundance on the coastal shelves bordering the bay, and the several common species of *Ampelisca*, *Paraphoxus*, *Photis* and other open-shelf amphipods are either missing or occur only as strays in Newport Bay. The dominant Newport Bay mud-bottom species are thought to be derived from open-sea depths below 10 m and not from the intertidal region or soft bottoms shallower than 10 m. The introduction of these calm-water elements into the bay is correlated with the introduction of pilings on which they live (Barnard, 1961).

Macdonald (1969a, b) made a quantitative study of mollusks occurring in the marsh area of Mission Bay. He found that the creek fauna contained more variable species-composition than the marsh (Table F1-6, App. 10, F.1). A comparison with other marsh mollusk faunas of the Pacific coast shows that the most abundant species, *Assiminea translucens*, in the Mission Bay marsh is the major gastropod of this area and the next abundant species, *Cerithidea californica*, which does not occur to the north of Point Conception, is close to its northern edge of distribution (Fig. II-10). The California horn snail, *C. californica*, is also abundant in Anaheim Bay and Newport Bay; it was reported to harbor eighteen species of trematode larvae (Martin, 1972).

The standing crop of the marsh mollusk fauna in Mission Bay, indicated by biomass (dry weight in gram/m²), remained almost constant

but that of the creek fauna showed a marked seasonal variation, being highest in the summer. This variation is resultant from changes in the abundance of *C. californica* and may reflect a seasonal migration of this species to lower elevations for breeding purposes.

The cosmopolitan species of mussel, *Mytilus edulis*, is very abundant in quiet-water of bays where there is hard substrate. It is one of the major fouling organisms occurring in the harbor. The community of *Mytilus edulis* is rich in epifauna. Reish (1964b) identified in Alamitos Bay 5 species of algae, 22 species of polychaetes, 9 species of amphipods, 11 species of mollusks, 6 species of ectoprocts, and 6 species of tunicates being associated with this bay mussel. A direct relationship between the number of associated species and water temperature was observed; the warmer the water, the greater was the diversity of species composition. Some species occurred in the mussel community throughout the year without seasonal fluctuation but others with definite spring or summer peak and still others occurred only seasonally, either in spring or summer.

The populations of sand dollar, *Dendraster excentricus*, occurred in the sand flat areas of Mission Bay Channel and Tijuana River Estuary were studied by Niesen (1969). A comparison with the off-shore population (of La Jolla Shores) indicated that there were differences in population size and size structure; the bay population was larger (about 25 individuals per 0.1 m²), remained stable with little fluctuation in size structure, and consisted of relatively larger robust individuals (65.7 ± 0.85 mm). These differences between the bay population and the outer coastal subtidal populations were attributed

by Niesen to the variance in the water movement, amount of food, and feeding behavior.

Vertebrates. Anaheim Bay and Newport Bay are the only two embayments in Southern California where a systematic survey on the fish has ever been attempted. A total of 68 species were recorded from Anaheim Bay by Klingbeil, Sandell & Wells (in press), and Dixon & Eckmayer (in press), and 61 species from Newport Bay by Bane (1968) and Frey, Hein & Spruill (1970). As expected, the fish fauna of these two bays are comparable, with more abundant species generally being common to both bays and very few species that are common in one bay but infrequently encountered in the other. All fishes recorded from the bays are not, in the strict sense, benthic forms. Some fishes, like flatfish and goby, are true macrobenthos; others, like killifish, topsmelt, and surfperch, although not strictly benthic in occurrence, are closely associated with substrate in that they all feed on benthic invertebrates.

The arrow goby, *Clevelandia ios*, is a very common fish in the bays of Southern California. It is the most abundant species of the gobiids occurring in Anaheim Bay, living either free on the bottom or commensally in the burrows of the echiurid worm (*Urechis caupo*), ghost shrimp (*Callinassa* sp.), or blue mudshrimp (*Upogebia pugettensis*). The pelagic larvae of this goby feed exclusively on the calanoid copepod, *Acartia tonsa*, whereas the adults, greater than 14 mm, are primarily benthic carnivores that feed on harpacticoids, cyclopoids, ostracods, nematodes, oligochaetes, and amphipods. They are in turn preyed upon by other larger carnivorous fishes (Macdonald, in press).

Anaheim Bay has high populations of two species of flatfish, the California halibut, *Paralichthys californicus*, and the diamond turbot, *Hypsopsetta guttulata*. It appears that the former feeds either on or above the substrate whereas the latter feeds either on or in the substrate. Thus the two species are ecologically separated insofar as competition for food is concerned. Studies on their stomach contents showed that the halibut fed mainly on fishes and crustaceans (Haaker, in press) and the turbot mainly on mollusks, polychaetes, and crustaceans (Lane, in press).

Carpelan (1961) made an observation on the fish in Los Penasquitos Lagoon with regard to their salinity tolerance. The lagoon is a variable type that was open to the ocean during the first six-month period (July-December, 1957) of observation and closed off during the following eight months. While pH and dissolved oxygen changed only slightly before and after the closure, salinity and temperature showed remarkable difference. The temperature difference was between 4 to 5°C and salinity rose from 35 ‰ to over 60 ‰. The majority of fishes (11 species) tolerated the changing salinity until it reached 55 ‰. *Hypsopsetta guttulata* withstood a little longer until 60 ‰. However, *Fundulus parvipinnis*, *Girella nigricans*, and *Atherinops affinis* were still thriving at 63 ‰ when the observation was terminated.

e. Permanent Dwellers and Seasonal Visitors

According to the length of their lifetime being spent in the bay, animals occurring in the embayment can be separated into permanent dwellers and seasonal visitors. Most of the animals living

in the bays and lagoons are recruited originally from the sea. They enter the bay either as an adult to spawn, to mate, to feed or as a larva to settle down. This recruitment of bay community may be year-round, in those species that have prolonged breeding seasons, or seasonal, in those species that only breed at certain times of the year.

Nektonic species (mostly fish) can move in and out of the embayment independent of the tidal current, but meroplankton rely entirely on the tidal current for their immigration and emigration. In Southern California bays and lagoons, it is characteristic in that salinity does not constitute an important factor in controlling the recruitment of neritic members; it is other parameters, such as temperature, dissolved oxygen, food, and sediment condition that control the composition of the community and abundance of each member in the community. The constriction of the bay mouth is particularly important in limiting the immigration and emigration of meroplankton.

The permanent dwellers are the major members of the bay community. It consists of all of the sessile invertebrates, the infauna, the tubicolous animals, and some fishes typically found in the bay.

i. Invertebrates

The bay mussel, *Mytilus edulis*, is perhaps the most conspicuous permanent dweller of the harbor and marina where hard surface is readily available. Upon establishment, the mussel provides a community to the bay with an assemblage of more than 60 species of various permanently dwelling macro-invertebrates (Reish, 1964b). On the soft bottom of Anaheim Bay and Newport Bay, however, the ghost shrimp

(*Callinassa* sp), the striped shore crab (*Pachygrapsus crassipes*), and the California horn snail (*Cerithidea californica*) are the most conspicuous permanent invertebrate dwellers.

Although the epifauna typically associated with the eelgrass, *Zostera marina*, in Anaheim Bay and Newport Bay is yet to be studied, works from other areas indicate that the eelgrass community in an embayment maintains a rich population of many permanent dwellers. Marsh (1973) recorded more than one hundred species of organisms associated with the eelgrass in an estuary in Virginia; this complex epibenthic community was quantitatively and qualitatively distinct from others in the area.

The isopod gribble, *Limnoria tripunctata*, is a serious woodboring pest in the harbors where contamination has been established and where salinities are not markedly reduced by influx of freshwater. The isopod is generally considered an inhabitant of shallow water but once established in a harbor, they quickly become a permanent dweller. Although they do not migrate out of the harbor, an extensive migration within the harbor has been observed. Johnson and Menzies (1956) found that *L. tripunctata* underwent a definite seasonal migration in San Diego Harbor. The migratory period reaches its height approximately during the season of highest water temperature (June and July) and the sexually mature adults make up about 97% of total migrant population. Most migrant females appear to have produced a brood prior to migration but at the time of migration they are not gravid. The factors influencing migration are probably a combination of approach to a

reproductive phase and population pressure due to over-crowding in old established population.

Insects are quite different from other animals of coastal embayments in that they are all originated from freshwater. Their abundance in salt marshes is very remarkable. Davis and Gray (1966) found some 250 species of insects on North Carolina salt marshes and concluded that they were abundant in both variety and quantity. Studies on the insects of salt marsh in Southern California is particularly scanty. Cox's (1969) study on the euryhaline water boatman, *Trichocorixa reticulata*, found in San Diego Bay, Mission Bay, Del Mar Lagoon, and San Elijo Lagoon is perhaps the only existing work on this subject. The water boatman is a permanent dweller of these bays and lagoons. It is generally a bottom dwelling insect, living in shallow, stagnant waters and coming to the surface only to replenish the gas film which envelops most of the body. It is primarily a detritus feeder but can filter feed on small plankton. Cox found that the nymphs were almost always present throughout the year in the bays and lagoons surveyed.

The sand dollar, *Dendraster excentricus*, is a permanent dweller of the bay. Several populations were observed by Niesen (1969) for a year in San Diego regions. It was noted that at almost all times, the sand dollars in Mission Bay remained in the upright position with their bodies oriented perpendicularly to the flow of the tidal current that came into the bay. This upright positioning of sand dollars forms a bed that provides an ideal shelter for many invertebrates. The species composition of these beds seems to reflect the locality of the population,

e.g., the anthozoan coelenterates and asteroids are associated only with the open shore beds but not with the estuarine beds (Table F1-3, App. 10, F.1).

ii. Vertebrates

Four of the seven most common teleosts recorded from Anaheim Bay are permanent dwellers in that bay. They are the topsmelt, *Atherinops affinis*, the California killifish, *Fundulus parvipinnis*, the arrow goby, *Clevelandia ios*, and the diamond turbot, *Hypsopsetta guttulata*. Studies on the life history of these fishes by Klingbeil (1972), Fritz (in press), Macdonald (in press), and Lane (in press) have shown that they complete their life cycle in the bay.

According to Haaker (in press), Anaheim Bay is used by California halibut, *Paralichthys californicus*, for a nursery ground. The young fish, about 12-40 mm long, come into the bay during April and May. They stay in the bay until they grow to about 200 mm long. Their emigration from the bay is assumed to be a maturation oriented movement. Another species of very common teleost, the Pacific staghorn sculpin, *Leptocottus armatus*, also uses the bay as a nursery area. Tasto (in press) found that the bay population of the staghorn sculpin consisted almost entirely of juvenile fish less than a year old.

The shiner perch, *Cymatogaster aggregata*, is also a very common fish of Anaheim Bay. Although it is a permanent dweller of the bay, the shiner perch exhibits a definite seasonal movement within the bay. They stay in the inner bay for most of the year but move out in the summer to shallow beach within the outer harbor (Dixon & Eckmayer, in press). The shiner perch is a viviparous fish that is ready to bear

its young in May (Odenweller, in press). Therefore, this movement in the bay during summer is a breeding migration.

The deepbody anchovy, *Anchoa compressa*, is a typical seasonal visitor to Anaheim Bay. They come into the bay for spawning during the summer months. Since none of them was collected from November to March (Klingbeil, 1972), it is assumed that the spent adults either move out of the bay or die soon after spawning.

The gray smoothhound, *Mustelus californicus*, is abundant in shallow water off Southern California and is the most common elasmobranch found in Anaheim Bay. Although there is no apparent diel pattern of abundance in the bay, a seasonal trend has been observed with two distinct peaks, a greater one in the spring and a lesser one in the summer (Sandell, 1973). It seems that the shark uses the bay as a mating and breeding ground and moves in and out of the bay readily when there is a drastic change in the environmental condition. The lack of capture of this shark in the bay in August, 1971, was attributed by Sandell to the outbreak of a red tide. The shark may have moved out of the bay through direct response to low dissolved oxygen or due to indirect result of lack of food. This shark was also observed to move out of the bay in the winter when the water temperature dropped down below 11°C.

The marshlands and mud flats of bays and lagoons attract many species of birds. It is an excellent habitat for residential birds and an ideal resting and feeding area for migratory shore and water birds. Over 150 species of birds have been seen in Anaheim Bay, 158 species in Upper Newport Bay, about 200 species in Buena Vista Lagoon, and 128

species in San Elijo Lagoon (Carlberg, 1940; Speth, 1969). Based upon the 1967-68 census conducted by the California Department of Fish and Game, a conservative estimate of close to 4 million bird-day-use was calculated for Upper Newport Bay. The shore birds accounted for 74% of this use and the ducks for the other 26%. The greatest use was found to occur between mid-September to April; e.g., on February 14, 1968, an estimated 56,250 birds were tallied, but by June 14, 1968, the count was only 550 birds (Frey, Hein & Spruill, 1970).

f. Ecological Succession

Generally, much less is known about the succession of communities in marine environment than in the terrestrial or freshwater regions. Of a few studies made in regard to marine ecological succession, almost all were made on the salt marsh flora or the epifauna, particularly the fouling organisms, of hard surface in littoral zone. As to the succession of level-bottom community, infaunal community, and plankton community, practically nothing is known. This paucity could be because many marine ecologists have not kept in their mind the concepts of the ecological succession and the climax community, or simply doubt its occurrence in marine communities (Hedgpeth, 1957).

i. Floral Succession in Marshland

According to his study on the salt marsh plants of San Diego County, Purer (1942) gave the following sequence for the succession of marsh flora. *Spartina*, the marsh plant that is most tolerant to water, is the pioneer. It grows on muddy surface, traps silt, accumulates dead parts of the grass, consolidates the mud, and

eventually raises the surface to form a stable level habitat. Then, the *Salicornia* gains a foothold in this Spartinetum. As the area has less and less water standing on it continually, pickleweed is found in pure stands. The pickleweed does not survive where it is totally submerged; it needs some aeration in the soil. The next stage is that in the upper edge of Salicornietum, there appears *Batis*, *Monanthochloe*, *Distichlis*, and *Suaeda*. These plants are usually partly submerged daily. *Limonium* is associated with all of the above except *Batis*, which maintains itself on slightly lower flats. Then on higher ground there are various species of *Artriplex*, associated with *Frankenia* and above, out of the reach of the storm waves.

ii. Faunal Succession in Harbors

Basing on his observations on the benthic fauna in a freshly excavated boat harbor in Alamitos Bay, Reish (1961a) reported that there was no indication of succession. The principal benthic species included 11 species of polychaetes, unidentified nemerteans, and one species of pelecypod; they were all dominant during the entire 3-year period of study. However, Carriker (1967) has expressed doubt that an ecological succession had not been found in the benthic communities of the harbor.

Scheer (1945) found an occurrence of true succession in the fouling organisms of Newport Harbor. He argued that the basic problem in the development of a sequence of marine animal communities in a limited environment was that of distinguishing between seasonal progression, and true succession. In the occurrence of a true succession, the

early forms must drop out and be replaced by later forms and, also, some of the earlier forms must be essential for the establishment of the later forms. If nothing of these sorts occurs, then the development is a seasonal succession. Scheer's view on the sequence of community development in Newport Harbor is summarized in Figure F1-14. According to him, a newly exposed surface is first colonized by bacteria, algae, and in some cases, hydroids. The development of these forms provides a favorable surface for establishment of bryozoan colonies and serpulids. The vigorous growth of the later forms eventually displaces the algae and hydroids. The resulting bryozoan community in turn provides a favorable basis for the attachment of *Mytilus* larvae. The growth of the mussels effectively covers the whole surface and eventually displaces the bryozoan community. Seasonal settlement of ascidian or barnacle larvae in tremendous numbers, may introduce variations into this sequence. *Ciona* may sometimes colonize a clean surface, or one covered with algae, to such an extent that the bryozoans are unable to maintain their foothold. *Styela* apparently settles only on bryozoan substrate, but may become established before *Mytilus*. Sponges are frequently associated with *Styela*. The ascidian communities are eventually displaced by *Mytilus*.

The *Mytilus edulis* community in Alamitos Bay Marina and *Mytilus californianus* in Marina del Rey were, however, reported by Reish (1964a, 1965) to exhibit seasonal progression rather than true succession. When the float in Alamitos Bay was scraped free of all macroscopic life in late winter, *M. edulis* appeared in about a month, but when it

was scraped in summer or early fall, the bay mussel did not appear until six to seven months later.

g. Productivity and Coastal Ecology

The inshore areas such as shallow seas, bays, lagoons, and estuaries are generally very productive. In favorable circumstances, net primary productivity may be comparable to a tropical rain forest (Mann, 1973). The bottom frequently supports a rich fauna, with benthic invertebrates alone often amounting to a standing crop biomass in excess of 100 grams of protoplasm (mainly pelecypods, polychaetes, and crustaceans) in each square meter of mud bottom (Russell-Hunter, 1970). Maintenance of such a large production of benthos in the shallow areas of the sea is made possible through the abundance of food and nutrient in the areas.

Perhaps of major importance is the fact that the very productive shallow areas commonly have abundant particulate organic detritus and other forms of organic matter, clay-rich mud, bacteria, and detritus and suspension feeders all within the photic zone. Basic nutrients released by bacterial decomposition are immediately available for fixation by the phytoplankton, algae, and other plants in the same area (Warne, 1971). There is no time lag as in deeper water, where nutrients released on the bottom must be brought into the photic zone by upwelling, overturn, or diffusion before fixing by photosynthesis. In the shallow coastal areas and embayments, the cycle is accelerated, and abundant food for the benthos results.

As mentioned earlier, in areas shallower than 100 meters zooplankton graze on only about 10% of the available phytoplankton (Williams, Murdock & Thomas, 1968). For instance, in an estuary where the estimated gross phytoplankton production ranges from 270 to 295 g C/m²/year, the estimated consumption of the primary production by the zooplankton herbivores is only about 30 g C/m²/year (Qasim, 1970). If it is assumed that most of the organic material which is produced in an ecosystem is likely to be consumed by the animal communities, then this large surplus of primary production must have been consumed by the benthic suspension and detritus feeders. Thus benthic herbivores rather than zooplankton represent the critical herbivore link in the shallow water food web (Fig. F1-15, App. 10, F.1).

In the marsh area, the primary production is even higher. The estimated *Spartina* production in the salt marsh of Georgia is about 897 g C/m²/year (Teal, 1962), and in the area with *Zostera*, it is estimated up to 1500 g C/m²/year in various parts of the United States (Mann, 1973). Odum and de la Cruz (1967) have shown that the build up of microbial population on detritus, consisting of dead fragments of leaves and stems of *Spartina* results in an increase in protein content from 6 to 24% of dry weight in detritus. Zobell and Felthm (1942) have also shown the importance of bacteria as food for animals dwelling in mud. Based on the counts of bacteria in cores 90 cm long taken from sediments in Mission Bay, they showed that there would be 1.1 gram dry weight of bacteria per cubic foot of sediment. Therefore, in a coastal embayment that is fringed with marshes and/or covered with eelgrass,

the total productivity would be much higher than those without.

The rich benthic invertebrate fauna in the shallow areas in turn serve as food for the demersal fishes and shore birds (Fig. F1-15, App. 10, F.1). In his quantitative study on the diamond turbot of Anaheim Bay, Lane (in press) estimated that an average fish consumes about 3.34 g/day of food consisting mainly of polychaetes, clam siphons, and crustaceans. The environmental cost for maintaining the estimated population of 5000-7000 individuals (50 mm and larger) was calculated and corrected for 12.9%. This means that for growing one gram of protoplasm, the turbot needs to consume 8 grams of polychaetes, clam siphons, and crustaceans combined.

An interesting phenomenon was discovered by Klingbeil (1972) in his comparative study on the food and feeding of the teleosts in Anaheim Bay. He found that the bay supported a variety of fishes whose dietary habits indicated very little competition for food (Table F1-9, App. 10, F.1). For example, both topsmelt and arrow goby are meiobenthos feeders, but the former takes mostly the ostracods, whereas the latter, nematodes and copepods. Competition between permanent dwellers and seasonal visitors is also slight. The frequent, seasonal visitors to the bay, such as *Mustelus californicus* and *Menticirrhus undulatus*, feed mainly on ghost shrimps, which are not regularly taken by the permanent dwellers. Although *Anchoa compressa*, another common seasonal visitor, feeds heavily on amphipods, it is not direct competition for food with *Fundulus parvipinnis* or *Atherinops affinis* in that they all have diverse diets. The anchovy is known to feed on polychaetes, mollusks, ostracods,

copepods, amphipods, and larvae of ghost shrimps. This existence of a small degree of competition for food among the fishes in the bay is an important factor in the maintenance of a balanced coastal ecosystem.

h. Mugu Lagoon

Mention should be made of Mugu Lagoon, a relatively unaltered bay not covered by Ho. Mac Ginitie and Mac Ginitie (1969) describe the environment of Mugu Lagoon as similar to the bays further south. Salinity is similar to that of the ocean outside. Rarely, heavy rains may result in lowered salinity killing bottom organisms in certain parts of the bay. The principal vegetation is similar down to the generic level, but *Ruppia maritima* appears to have greater importance in Mugu Lagoon. A list of the abundant vegetation is presented in Table F1-10a (App. 10, F.1).

Seasonal abundance of plankton is similar to the bays discussed by Ho. Red tides were reported as well as early summer blooms of the luminescent protozoan, *Noctiluca*.

Many of the usually benthic invertebrates are similar in Mugu Lagoon and other southern estuaries; but the dominant organisms sometimes differ. This is particularly true with the polychaeta worms, as a comparison of Tables F1-5 and F1-10^{10 b} (App. 10, F.1) indicates. Certain members of the Mugu Lagoon biota undoubtedly reflect a more northern component.

i. Summary

There are nineteen major coastal embayments in Southern California. Only three of them have remained relatively

unaltered, i.e., Anaheim Bay, Upper Newport Bay, and Tijuana Estuary. Since very little biological survey of the marshes and bays was done in the past, a checklisted information of the flora and fauna of the area cannot be prepared.

The biota of Anaheim Bay are comparatively better known and probably represent a possible flora and fauna of the Southern California coastal embayments before alteration. Several species of fish utilize the bay for spawning and nursery grounds and a great many species of birds use it as nesting, feeding, and shelter area.

Polychaeta is the single most studied group of organisms, for certain species of them can be used as indicators of the bottom condition for monitoring pollution. A new form of extremely rare Crustacea was recovered from Anaheim Bay. It belongs to Cephalocarida, which is the most primitive living Crustacea of the world.

The existing condition of biological knowledge underscores the difficulty in understanding the ecosystem of the coastal embayments and their relationship with the total coastal ecology, since a biological inventory is lacking and only a few species are known to a level of quantitative characterization, e.g., biomass, density per unit area, environmental cost, etc.

2. Kelp Beds

Various aspects of kelp beds have been covered in detail in other sections of the EIS. The large attached algae were covered in II.E.3.a. (Murray, 1974), associated invertebrates in II.E.3.b. (Bright, 1974), associated fish in II.E.4., and commercial kelp operations in II.G.5. (Murray, 1974). Impacts are discussed in Section III.D.5.

We feel kelp beds are such an important marine habitat to Southern California that a generalized overview section should be included. Associated with kelp beds in Southern California and northern Baja, California are over 810 kinds of organisms. This species count was taken from North (1971) who listed 128 species of macrophytes (20 common), Quast (1968) who listed 57 species of fishes, and Bright who listed over 625 invertebrate species (74 common) associated with kelp beds. The majority of these species may not have an obligatory relationship with giant kelps, but they utilize every conceivable nook and crevice of the plant and adjacent area thereby greatly increasing the total habitat available to them.

Unless otherwise stated the following overview was taken from Frey (1971). Kelp harvesting has been centered in Southern California. Kelp grows in water from just outside the surf to depths of 100 feet, or about 33 meters. The plant has a root-like structure called a hold-fast which clings to a hard rock or shale substrate.

Giant kelp is a perennial, living and sending up new stalks called stipes for a period of five to ten years. These stipes reach the surface to form a canopy, and live for about six months. There is a constant succession of new stipes growing to the surface to replace

dead and dying ones, and a single holdfast may have more than 100 stipes. A young plant takes about one year to become established. Under favorable conditions, a young plant will double in size every three weeks. Growth and reproduction are limited by the available light (water clarity and depth), temperature, amount of available rocky substrate, nutrients present, number of grazers in area (opaleye, sea urchins, abalone, and other gastropods), disease (black rot), storms, and by heated water discharges and sewage outflows in the area. During periods of optimum conditions, which consist of clear, cool waters below 66°F (18.9°C) enriched with nutrients upwelled to the surface, giant kelp stipes have been observed to grow from 12 to 24 inches in a single day. In Southern California when water temperatures reach 66°F, growth is arrested and sloughing occurs. Grazers, such as sea urchins, may have a tremendous impact on kelp beds when ecological conditions permit their populations to reach large numbers. Environmental conditions created by sewage outfalls in Southern California have lead to the establishment of large urchin populations in certain areas. Urchins not only destroy the existing kelp, but also keep young plants from becoming established. Once the kelp is gone, the urchins are able to survive by living off the sewage discharge nutrients. Research indicates an urchin also may absorb up to 50 percent of its minimum daily nutrient requirements from the surrounding water. In this manner, large urchin populations continue to exist in areas that formerly contained kelp beds.

Moderate success has been achieved in controlling sea urchin populations and restoring kelp beds. The kelp bed at Point Loma, near San

Diego, has been restored to almost the same size it was 20 years ago. In addition to physically or chemically killing the sea urchins, several other techniques have been developed to assist in kelp restoration. One side effect of disappearing kelp beds is the loss of fish habitat. Areas that once sustained considerable sport and partyboat fishing pressures now provide very little support to these fisheries.

California kelp beds have decreased in size since the early 1900's from approximately 100 to 75 miles (California Coastal Zone Conservation Commission, 1975). There are 74 designated kelp beds along the California coastline. These cover 53.86 square miles south of Point Conception, including the offshore islands, and 15.5 square miles between Point Conception and Point Montara. In the last ten years, some of the major kelp beds of Southern California have all but disappeared due to temperature changes, sewage discharges, and kelp grazers. Kelp habitat improvement projects, initiated in 1963 by industry and the academic society, have restored the Point Loma kelp bed near San Diego to a point where it again can sustain a commercial harvest. Increased numbers of heated water discharges could pose a threat to the kelp resources of California in the future unless special effort is made to keep the warm effluent away from kelp beds.

Giant kelp is harvested by specially built barges. These vary in size and some are capable of carrying up to 300 tons of wet kelp. Kelp is cut to a maximum depth of four feet (by regulation) below the water's surface and is transferred by a conveyor belt into the open hold of the barge. It then is transported to a processing plant where it is transformed to a saleable product. The California harvest has been fairly

steady since 1960 and has averaged 129,000 wet tons. Murray (1974) reports the 1972 harvest was 162,511 wet tons.

Kelp contains carbohydrates, minerals, vitamins, and algin or alginic acid. During World War I, potash, acetone, and iodine were the chief products recovered from kelp. Kelp meal, used as an animal food supplement, and algin, used in many modern products, are the most important items today.

Algin, a colloidal substance extracted from kelp, has the unique property of absorbing large quantities of water. This property makes it important in preparing commercial ice cream since it prevents water from forming coarse ice crystals. Algin also has suspending, stabilizing, emulsifying, gel-producing, film-forming, and colloid-forming properties which render it valuable in other processes. It is used in pharmaceuticals to suspend drugs and antibiotics such as penicillin. Algin is important in the preparation of adhesives for containers, coatings for welding rods, and to hold fiberglass mats together. The textile industry uses it for thickening and stabilizing dyes. At present, there are more than 200 uses for algin.

While giant kelp isn't the only economically important marine plant resource in California, it presently supports the state's largest marine plant industry. The exact value of the resource has not been determined since much of the value is based upon the finished products. If unrefined kelp is used as a supplemental animal food, it has a relatively low economic value when compared to the colloid compounds extracted from kelp and used in food, industrial, and pharmaceutical products. This renewable resource is important not only to the marine plant in-

dustry, but also to the marine sportsfishing industry (partyboat) since many sport fish are found in association with kelp beds.

Fish utilize marine algae for shelter, food, and a place to lay their eggs. Many sport fishes may be found in or near giant kelp beds. Because of its importance as a fish habitat, in the past there has been considerable opposition to harvesting kelp by individuals and groups who feared depletion of the kelp beds and consequent undesirable ecological conditions. These apprehensions have proven to be unwarranted; in fact, studies have indicated judicious harvesting may actually benefit the beds.

3. Channel Islands

a. Introduction

Eight islands are contained within the Southern California Bight (see II.G.1. for Land Use). San Miguel, Santa Rosa, Santa Cruz and Anacapa comprise the northern-most islands and are collectively known as the Northern Channel Islands while Santa Barbara, San Clemente, San Nicholas, and Santa Catalina, are known collectively as the Southern Channel Islands.

b. Geology

These islands are bounded by deep fault formed basins and are the product of tectonic emergence initiated some 11-20 million years ago. As islands they were thought to have first appeared some two to three million years ago in the late Pliocene - early Pleistocene (Valentine and Lipp, 1967).

Fossiliferous marine sediments occur on all the islands in conjunction with extensive marine terracing. The marine terracing was caused by tectonic emergence and sea level fluctuations during the period of Pleistocene glaciation and is found as high as 1800 ft. on the north side of Santa Cruz Island (Weaver and Doerner, 1967).

The general geologic and structural style of the Northern Channel islands suggest that they are a westward extension of the Santa Monica Mountains, with a granitic core (exposed on Santa Cruz Island) intruded into what are now slates, phyllites and schists, overlain by Cretaceous and Cenozoic sedimentary and volcanic rocks (Valentine & Lipp, 1967).

The Southern Channel Islands and intervening basins have a more complex history but are generally considered to be a westward expression of the NW-SE orientation of the San Bernardino, San Gabriel and Santa

Ana mountains with their silted in basins and flood plains (San Fernando Valley, Los Angeles flood plain, Coachalla Valley). These islands together with the Palos Verdes Hills area (which was an island itself at one time) have a basement of metamorphic rock of the "Franciscan" type, which is evident on Santa Catalina Island and the Palos Verdes Hills.

The history of these islands is interesting in that they are areas which at one time in geologic history were connected to the mainland in pre-Illinoan Time during the Pleistocene (Orr, 1967). By the late Pleistocene and sub-recent times mainland connections had existed sufficiently long enough for a Pleistocene Mammalian fauna to establish itself as far west as San Miguel (Weaver & Doener, 1967). The islands provide a valuable archaeological laboratory as evidence by Orr's work on Santa Rose Island (Orr, 1968).

c. Archeology

In addition to his own archeological finds, Orr lists the various fossils discovered by other workers on Santa Rosa Island. He also includes a commentary on the relationship of the fossil discoveries to the archeological finds and history of the other Channel Islands. Among the most interesting of the numerous fossils discovered are the dwarf mammoth (*Mammuthus exilis*) and the giant mouse (*Peromyscus nesodytos*) both endemic to the Channel Islands, and the extinct gannet *Morus reyanus* (one of three fossil sites in the U. S. for this species).

Archaeological field work on the islands dates back to the late 1800's, Orr's work on Santa Rosa Island being by far the most extensive.

Over a period of 21 years 200 ancient village sites have been identified, representing at least four distinct cultures occupying Santa Rosa Island between 7,400 and 150 years ago (Orr, 1968).

Other archaeological work on the Channel Islands has been carried on intermittently since the 1930's by the San Diego Museum of Man and the Los Angeles County Museum. During the last twenty years more concentrated studies have been conducted by the University of California at Los Angeles, the Southwest Museum, and the Los Angeles County Museum. Rozaire (1967) states that the Channel Islands give evidence of having been among the most heavily populated areas in aboriginal North America.

d. Marine Flora and Fauna

The marine flora and fauna (see Section II.E.1-6) of the Channel Islands are of significance in that they are astride a major break in the biogeography of the Pacific Coast, the Point Arugello-Point Conception break (Neusal, et al. 1967). This biogeographical break or coastal species composition change is thought to be due to the ocean temperature current characteristics of the cold south moving California current (see Section II.C.1. for current description).

Extensive upwelling along the central and particularly the northern coast of California contributes large amounts of cold water to the south moving California current. The coldest temperatures south of British Columbia occur in the Cape Mendocino region (Hubbs, 1967). The California current flows south along the central California coast as far as Point Conception, where the coastline swings abruptly eastward. It then continues in a south-easterly flow bathing San Miguel, San Nicholas, the Northern sides of Santa Rosa, and Santa Cruz in water temperatures markedly colder than the adjacent coast. Hubbs (1967) cites that on one oceanographic survey along the Northern Channel Islands, a surface

water temperature increases of 8° C. was recorded between the west end of Santa Cruz and the Anacapa Region.

This occurrence of extensive upwelling and associated large amounts of cold water provide nutrient rich areas around the offshore Channel Islands. These nutrient rich areas contain large populations of plankton which in turn serve as a plentiful food supply for marine fish, birds and mammals. The added close proximity of the Channel Islands to these rich food supplies make these islands unique and critical habitat for the thousands of marine birds and mammals which use them as breeding and nesting grounds.

Benthic fauna and flora typical of the colder northern coastline and absent from the adjacent coastline characterize the marine biota of San Nicolas, San Miguel and portions of Santa Rosa, Santa Cruz and Anacapa. The marine biota of San Clemente and Santa Catalina Islands are influenced throughout most of the year by the warm southern water of the California countercurrent. The ocean current system and temperature structure of the Bight area is complex due to seasonal variations and periods of upwelling. However, many of the characteristics of the current system and temperature structure are evident in the benthos composition, distribution, and abundance within the Channel Islands. Enumeration of the various benthic organisms in the Channel Islands has been done in a limited scale for San Nicolas, Anacapa, and Santa Cruz. Neushal et al. (1967) have enumerated the flora and fauna of the Channel Islands and point out their uniqueness as differentiated from the coastal benthos south of Point Conception outlined in Section II.E. (Table F 3-1, Appendix 10, Section II.F.3.).

e. Terrestrial Flora

The vegetation of the Channel Islands in general is composed of coastal sage scrub with chapparral and oak woodland occurring on the large islands of Santa Rosa, Santa Cruz, San Clemente and Santa Catalina. Stands of closed cone pines, *Pinus torreyana* ^{1/} and *Pinus miricata* (confined to Santa Rosa), occur on Santa Cruz and Santa Rosa. Because of the moderating effects of the sea and a greater rainfall, the islands have a milder and wetter climate than the immediately adjacent mainland areas. This is reflected in both the vegetation and the animal composition of the islands.

Raven (1967) summarizes the floristics of the Channel Islands by listing the plants endemic to the Channel Islands (see Table F 3-2, Appendix 10, Section II.F.3.); and stating that of all the islands, San Nicolas is perhaps the least diverse ecologically, that San Clemente has the highest number of endemics; and that San Miguel and Anacapa the least number of endemics (see following table).*

<u>Island</u>	<u>Number of native species subspecies and varieties</u>	<u>Number of endemic species subspecies and varieties</u>
Santa Cruz	420	7
Santa Rosa	340	3
Santa Catalina	375	3
San Clemente	233	11
San Nicolas	120	2
San Miguel	190	-
Anacapa	70	-
Santa Barbara	40	1

*Compiled from Raven (1967)

The flora of Santa Cruz, Santa Rosa and Santa Catalina Islands are relatively similar to those prevalent on the mainland at the present time, whereas those of San Clemente

^{1/} *Pinus tarreyona*; as well as a number of other plant species endemic to the Channel Islands are included on the California Nature Plant Society's list of rare and endangered species.

and Guadalupe Islands consist of mixtures of various elements present on the mainland past, as well as distinctive endemics that may have evolved in situ. The floras of the four smaller, recently submerged islands are much poorer in endemics which is consistent with their recent arrival from nearby islands and from the mainland in relatively recent time (Raven, 1967).

f. Terrestrial Fauna

The herpetofauna (amphibians & reptiles) of the Channel Islands has been reviewed by Savage (1967) who cites nine different species for the Northern Channel Islands. He includes two species of salamanders, one species of frog, three species of lizards, and three species of snakes. The Southern Channel Islands are represented by two species of salamanders, one species of frog, four species of lizards, and five species of snakes totaling 12 different species. The majority of the species are found on the adjacent mainland with only two endemics, the genus of lizard (*Klauberina*-endemic to San Nicolas, Santa Barbara, San Clemente) and the salamander species *Batrachoseps* sp. endemic to Santa Cruz (Savage, 1967). The herpetofauna of the Channel Islands is summarized in table F 3-3, (Appendix 10, Section II.F.3.).

Comparing the herpetofauna of the Channel Islands with the adjacent mainland, Savage (1967) characterizes the herpetofauna as being few in number. Comparable habitats on the mainland opposite to the Northern Channel Islands support a fauna of 20 species (Ventura County) while Santa Cruz, the largest of the Northern Islands, supports a total of 9 different species of amphibians and reptiles. However, in comparing such factors as insular surface area and the distance from the mainland to species diversity, San Miguel, Santa Catalina, and Santa Cruz Islands support herpetofauna directly proportional to area. Santa Barbara and Anacapa have significantly larger herpetofauna populations than would be expected if only these factors are considered. San Nicolas and Santa Rosa have significantly fewer herpetofaunal species than would be anticipated on the basis of island size (Savage, 1967).

The Channel Islands also provide habitats for a variety of terrestrial and marine related bird species which have been listed in Section II.E.5. Studies on the various aspects of bird ecology on the Channel Islands date back to work by such investigators as Howell (1917), Maillard (1918), Cooper (1870), Pemberton (1931) and Grinnell (1944). More recent work has been conducted by Townsend (1968), Diamond (1969), Harper (1971), Power (1972), Johnson (1972), Jehl (1973) and Hunt (1974). However, the last official comprehensive list of birds present is from the American Ornithological Union 1957 checklist of North American Birds, some seventeen years ago.

Johnson (1972) does present a valuable list of the avifauna endemic to the Channel Islands (Table F 3-4, Appendix 10, Section II.F.3.) citing 18 endemic subspecies representing 13 different species. Johnson states that the degree of observed endemism due to insular evolution is striking and that the divergent evolutionary trend is towards individuals with darker or greyer plumage, heavier bills, heavier tarsi and/or feet.

A comparison of early avifauna records with more recent surveys shows that the species composition of the islands does change. This change may be due to invasion of new species from the mainland, human activities encroaching upon breeding areas, arrival or extinction of competitive or predator species, disappearance or decrease of native habitats, introduction of new species by man, and natural species extinction.

The presently known land mammal fauna of the Channel Islands totals 34 species (Von Blocker, 1967) which include the sea otter, a rare visitor. Of these 34 species (see Tables F 3-5 and F 3-6, Appendix 10, Section

II.F.3.), 14 are native to California with the remainder being man and 19 introduced species. On species *Urocyon littoralis* (the Island Fox) is endemic to the Channel Islands and has been classified as a rare animal under authority of the California Endangered Species Act (Laughrin, 1973).

The Island Fox inhabits six of the eight Channel Islands (see Table II-81). There is a different endemic subspecies for each island: San Miguel- *U.l. littoralis*, Santa Rosa- *U.l. santarosae*, Santa Cruz- *U.l. santacruzae*, San Nicolas- *U.l. dickeyi*, Santa Catalina- *U.l. catalinae*, San Clemente- *U.l. clementae*. Laughrin (1973) states that all of the island fox populations appear to be normal and healthy with the exception of the Santa Catalina Island Fox *Urocyon littoralis catalinae* which may prove to be endangered.

The most common mammal of the Channel Islands is the deer mouse (*Peromyscus maniculatus* spp), of which there is a separate subspecies listed for each of the eight islands. Deer mice frequent every type of habitat on the islands from the ocean beaches to the tops of the highest mountains, scavenging a variety of seeds, leaves, twigs, insects, and littoral debris.

Probably the rarest of the mammals associated with Channel Islands is the sea otter (*Enhydra lutris*). The sea otter of California is recognized as a separate subspecies *Enhydra lutris nereis*, distinguished from its northern relative *Enhydra lutris lutris* by a larger size and a more brownish coloration (von Bloeker, 1967). The original range of the sea otter extended from the northern islands of Japan, through the Aleutians, and down the coast of North America to Baja California. Its

range was more or less continuous with kelp beds, its prime habitat.

The sea otter spends the majority of its life time in the sea, rarely coming ashore. Unlike other marine mammals which possess a thick insulating layer of fat, the sea otter depends entirely on a very thick and luxurious coat of fur for protection against the cold water of its environment. The fur, which is possibly the finest in the world, consists of a very dense fine underfur of inch-long fibers and very sparse guard hairs. For this reason the sea otter's fur has been highly sought after in past centuries. In 1891 extra-fine skins brought as high as \$1,125; in 1910 one brought the record price of \$1,703 (Daugherty, 1966).

During the 18th and 19th century it was virtually exterminated south of Alaska and dangerously threatened in the remainder of its range. Finally in 1911, the sea otter was given its first complete protection under the "Fur Seal Treaty" signed between the United States, Great Britain, Russia and Japan. This has since been supplemented by both Federal and State laws dating back to 1913. In California the sea otter population is presently making a come back, but is restricted to the coast of Monterey and San Luis Obispo counties, a portion of which has been designated as the California Sea Otter Game Refuge (from Carmel River in the north, and south to Santa Rosa Creek).

Various sightings of sea otters in the Channel Islands area have been made in recent years. In 1954, biologists saw two at San Miguel Island and one was reported off of Anacapa in the 1950's by Fish & Game Wardens (Daugherty, 1966). Other sightings have occurred in the Channel Islands in recent years near San Miguel, San Nicolas and San

Clemente (von Bloeker, 1967; Bortholomew, 1967). There is definitely no large resident population of sea otters within the Channel Islands, but the increase in frequency of sightings and the existence of a breeding population a little to the north holds promise for a possible re-establishment of the sea otter into its former range.

The Channel Islands are important environmentally in that their relative inaccessability has in general preserved many of the natural ecosystems from total human encroachment. They are not pristine in the sense of our National Wilderness Areas, but they are relatively untouched compared to the huge metropolitan sprawl of the adjacent mainland.

Man in the past has changed the ecology of the islands, from the decimation of the sea otter population to the introduction of goats, sheep, and cattle which have affected the indigenous flora and fauna of the islands. The feral house cat present on all of the islands undoubtedly has played a part in the disappearance of various bird species. The introduction of halogenated hydrocarbons into the marine food chain is presently playing havoc with the reproductive capability of such bird species as the brown pelican (*Pelicanus occidentalis*) Jehl (1973), and the double crested cormorants (*Phalacrocorax auritis*) Grass et al. (1973).

And yet the Channel Islands do provide habitats for a myriad of animal and plant species native to Southern California but presently absent on the adjacent mainland. Efforts are underway to protect the existing island biota and in some instances to restore native flora and fauna (National Park Service, Channel Islands National Monument).

A summary of why these islands are important to us would include:

1. Site of the only brown pelican rookery in California
(Calif. Dept. of Fish and Game, 1973)
2. Home for eighteen endemic subspecies of terrestrial birds
(Johnson, 1972)
3. Breeding and roosting sites for over 30 species of sea
birds (Bender et al., 1974)
4. Breeding sites for the elephant seal and California sea
lion (Calif. Dept. of Fish and Game, 1973)
5. The only northern fur seal breeding colony south of the
Pribilof Islands, Alaska (Calif. Dept. of Fish and Game, 1973)
6. Only area north of Mexico still visited by the rare
Guadalupe fur seal (Fiscus, 1975)
7. Seventy-six insular endemic and rare plants (Raven, 1967)
8. Largest single stand of giant coreopsis, *Coreopsis gig-
antea* (National Park Service)
9. One of the two living stands of torrey pine (*Pinus tor-
reyana*) Orr, 1968
10. 200 identified Indian village sites of the Canallion
Indian culture (Orr, 1968)
11. Archeological finds of early man dating back 12,000 years
(Orr, 1968)
12. Numerous interesting fossil sites containing the remains
of such animals as the dwarf mammoth (*Mammithus exilis*) the giant mouse
(*Peromyscus nesodytes*), and one of the three fossil sites in the United
States for the extinct gannet (*Morus reyarous*) Orr 1968

13. Nearly two fifths of the fifty four square miles of major kelp beds recorded for this area occur around the Channel Islands (Neushal et al., 1967).

There are currently available numerous sources of literature on the biology, geology and archaeology of the Channel Islands with most of the references being contained within the papers presented at the Symposium on the Biology of the California Islands edited by Philbrick (1973). Laughrin (1973) during his study of the island fox probably presents the best overall paper on the Channel Islands for those of you who wish to learn more of these fascinating islands off our Southern California coast.

4. Mainland Terrestrial Biomes

It is important to realize that large areas of the natural land vegetation in Southern California have been interrupted by urbanization or agriculture (Fig. II-75. As described by the Bureau of Land Management, biomes are used to delineate the land vegetation rather than small, extremely patchy distributed plant communities. The latter are, after all, smaller entities within the larger more inclusive vegetation biomes. A generalized account of the terrestrial wildlife (excluding birds) will be correlated with the vegetation biomes.

The Woodland-Bushland Biome is variable with three vegetation types, California Chaparral, forest vegetation, and riparian woodland, often occurring intermixed within very close geographical areas (Bureau of Land Management, 1973). Some of this biome especially in the more northern part of the states, exists as a sub-climax stage of the coniferous forest, the forests having originally been destroyed by forest fires, timbering, and other man-made alterations.

The vegetation, though variable, is typically adapted to withstand summer periods of drought. The leaves are thick and highly cutinized. The most prevalent vegetation association, comprising about 50% of the biome, is California Chaparral occurring predominantly in the drier areas having a maximum of 11 inches of precipitation a year. The most common plants of the chaparral include: chamise, toyon, several species of *Ceanothus*, manzanita, and scrub oak. These plants oftentimes occur in densities which make the areas impenetrable by all but small animals.

The forest vegetation type generally consists of scrub oak, island oak, toyon, ironwood, manzanita, and chamise.

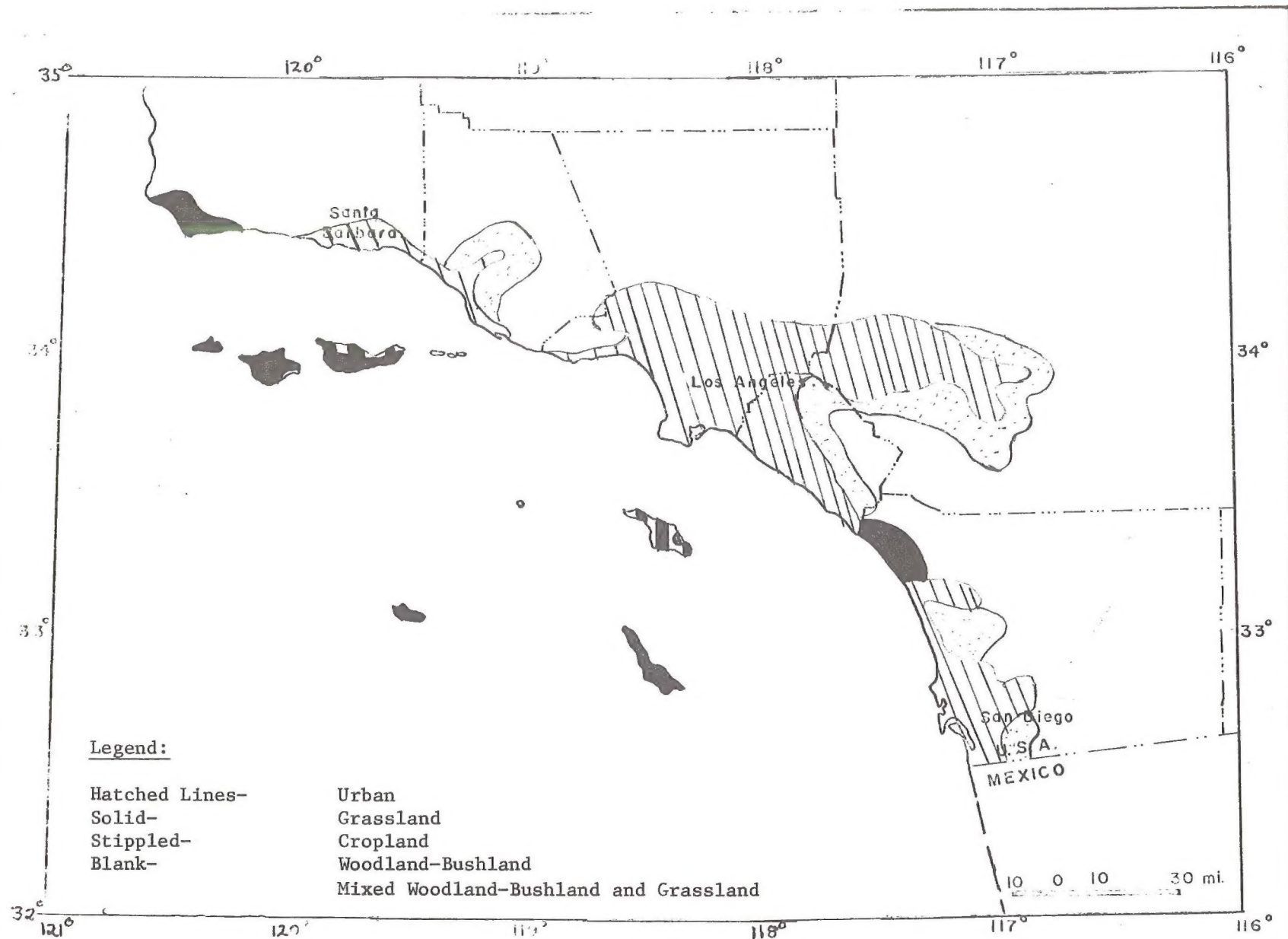


Figure II-75 Coastal Vegetation Biomes of Southern California
 From: Bureau of Land Management (1973) and Laughrin (1973).

Another common vegetation type is the riparian woodland. Common plants are willows, alders, blackberry, creek dogwood, blue elderberry, nettles, various ferns, and cottonwood.

Because the mainland woodland-bushland biome is so widespread and has such a wide variety of vegetation, the wildlife is also represented by a long list of species. No one species, however, is unique to any one vegetation type or representative of the biome. The dominant mammal of the biome is the deer. The California mule deer is found near the coast in Santa Barbara and Ventura counties. The blacktailed deer is common throughout the remainder of the area.

Some common large mammals of California's woodland and bushlands are the cougar, black bear and coyote. Others are the gray fox, spotted and striped skunks, bobcat, jack rabbit, California ground squirrel, pocket gopher, raccoon, gray squirrel and opossum.

The Western fence lizard and rattlesnake are the most common reptiles. The species using this habitat which are threatened with extinction are the California condor, Southern bald eagle, and peregrine falcon. Nearly all of the streams which have perennial water, support populations of trout or warm water game fish (Bureau of Land Management, 1973). The grasslands of Southern California vary from tall dense grasses to low sparse grass. Most of the native grasses (commonly the bunchgrass type) have been replaced by introduced species. The species composition is varied and there are no species which are typical of the grasslands.

The species on the Channel Islands are apparently similar to those of the mainland although Laughrin (1973) reports several endemic species

(species located only on these islands). On the steep walls and cliffs of these canyons, but out of reach of the persistent goats, precariously remain some of the unique and interesting island endemics such as the tree dandelion (*Manzothamum blairii*), island snapdragon (*Galvezia*), island buckwheat (*Eriogonum giganteum*), and monkey flower (*Mimulus flemingii*). A complete discussion of San Clemente's flora is given by Raven (1963). See Section II.F.3.

The animals of the mainland grassland biome are the same species which occur in the woodland-bushland biome except that there are fewer deer and no black bears or cougar. Another exception is a greater variety of rodents and burrowing animals.

Dames and Moore (1973) list amphibians and reptiles (Table F 4-1), and mammals (Table F 4-2) typical of the Santa Barbara region. Various ecological information about the species is included. The Riparian Oak Woodlands and Chaparral are included in the Woodland-Bushland Biome on Fig. F 4-4. Near Long Beach, adjacent to Anaheim Bay at Bolsa Chica, Dillingham Corporation (1971) listed the amphibians and reptiles (Table F 4-3) and mammals (Table F 4-4) during 1970. All tables listed in this paragraph are found in Appendix 10, Section II.F.4.

5. Unique Environments

The California Department of Fish and Game has delineated location of the State's Marine Life refuges, reserves, and ecological reserves and defined the regulations concerning their use (Smith and Johnson, 1972). Impacts are discussed in Section III.I.5. The purpose of the refuges and reserves is to reduce the abuse and waste of the state's tide pool resources by restricting general collecting of all animals living in tide pools and other areas between the high tide mark and 1,000 feet below the low tide mark without a special permit from the Department of Fish and Game. Pertinent rules from the Fish and Game code are quoted below.

ECOLOGICAL RESERVES

For the purpose of protecting rare or endangered wildlife, aquatic organisms, or specialized habitat types both terrestrial and aquatic, the Department, with the approval of the Commission, may obtain by purchase, lease, gift or otherwise, land and water for the purpose of establishing ecological reserves. Such ecological reserves shall not be classed as wildlife management areas pursuant to Section 1504 and shall be exempt from the provisions of Section 1504.

Except in accordance with the regulations of the Commission it is unlawful to enter upon any ecological reserves established under the provisions of this article, or to take therein any bird or the nest or eggs thereof, or any mammal, fish, mollusks, crustaceans, amphibia, reptiles or any other form of plant or animal life.

As used in this article, "ecological reserve" refers to land or land and water areas preserved in a natural condition for the benefit of the general public to observe native flora and fauna and for scien-

tific study. Public entry and use of ecological reserves shall be compatible with the primary purposes of such reserves subject to the following applicable general rules and regulations in addition to any special regulations which are prescribed for a specific area.

- (a) Taking of plant and animal life. No person shall disturb geological formations or archeological artifacts or take or disturb any bird or nest or eggs thereof or any plants, mammal, fish, mollusk, crustacean, amphibian, reptile, or any other form of plant or animal life in an ecological reserve, except as provided.
- (b) Fishing. Fishing shall be allowed in accordance with the general fishing regulations of the Commission except that the method of taking fish shall be limited to angling from the shore. No person shall take fish for commercial purposes in any ecological reserve except by permit from the Fish and Game Commission.
- (c) Collecting. No collecting shall be done in an ecological reserve except by permit from the Fish and Game Commission. Any person applying for permit must have a valid scientific collecting permit issued pursuant to part 3 of this title.
- (d) Motor Vehicles. No person shall drive, operate, leave or stop any motor vehicle, bicycle, tractor, or other type of vehicle in an ecological reserve except on designated access roads and parking area.
- (e) Swimming. No person shall swim, wade, dive, or use any diving equipment within an ecological reserve except as

authorized under the terms of a permit issued pursuant to subsection (c).

- (f) Boating. No person shall launch or operate a boat within an ecological reserve except by permit from the Fish and Game Commission.
- (g) Trails. The Department may designate areas within an ecological reserve where added protection of plant or animal life is desirable, and may establish hiking or walking trails or paths within such designated areas. No person shall walk or hike in such areas except upon the established trails or paths.
- (h) Firearms. No person, excluding authorized personnel, shall use, fire or discharge any firearm, bow and arrow, air or gas gun, spear gun, or any other weapon of any kind within or into an ecological reserve.
- (i) Ejection. Employees of the Department may eject any person from an ecological reserve for violation of any of these rules or regulations or for disorderly conduct, intoxication or for any reason when it appears that the general safety or welfare of the ecological reserve or persons thereon is endangered. The decision, in such respect, of any Department employee assigned management or enforcement responsibilities for the ecological reserve shall be final.
- (j) Public Entry. Public entry for any or all purposes may be restricted on any or all of the area at the discretion of the Department to protect the wildlife, aquatic life, or habitat

of the area.

MARINE LIFE REFUGES

The following general regulations and provisions apply to refuges and other protected areas. Except under a permit or specific authorization, it is unlawful:

- (a) To take or possess any bird or mammal, or part thereof, in any game refuge.
- (b) To use or have in possession in a game refuge, any firearm, bow and arrow, or any trap or other contrivance designed to be, or capable of being, used to take birds or mammals, or to discharge any firearm or to release any arrow into any game refuge.
- (c) To take or possess any species of fish or amphibia, or part thereof, in any fish refuge, or to use or have in possession in such refuge any contrivance designed to be used for catching fish.
- (d) To take or possess any bird in, or to discharge any firearm or to release any arrow within or into, any fowl refuge.
- (e) To take or possess any quail in a quail refuge.
- (f) To take or possess any invertebrate or specimen of marine plant life in a marine life refuge.
- (g) To take or possess any clam in a clam refuge or to possess in such a refuge any instrument or apparatus capable of being used to dig clams.

The Commission may:

- (a) Exercise control over all mammals and birds in any game

refuge, and exercise control over all fish in any fish refuge.

- (b) Authorize the Department to issue, under such restrictions as it may deem best, permits which shall authorize the person named therein to carry, use, and possess within any refuge, firearms, traps or other contrivances for taking birds, mammals, fish or amphibia.
- (c) Authorize the Department to issue permits which shall authorize the person named therein to take birds, mammals, fish and amphibia within any refuge.
- (d) Make additional regulations not in conflict with any law for the protection of birds, mammals, fish, amphibia, and marine life within any refuge.

In the San Diego Marine Life Refuge, licensees of the Regents of the University of California and all officers, employees, and students of such University may take, for scientific purposes, any invertebrate or specimen of marine plant life without a permit from the Department.

In the Laguna Beach, Newport Beach, Point Fermin, South Laguna Beach, Dana Point, Niguel, Irvine Coast, and Doheny Beach Marine Life Refuges the following fish, mollusks and crustaceans may be taken under the authority of a sport fishing license as authorized by this code: abalone, lobster, bonita, rockfish (*Sebastes*), mackerel, perch, kelp bass, sand bass, spotted bass, corbina, croaker and halibut. All other fish and forms of aquatic life are protected and may not be taken without a written permit from the Department.

The following summary of the marine life refuges and reserves was taken from the California Department of Fish and Game (1973).

Point Fermin Marine Refuge (Fig. II-76)

This marine life refuge lies to the north of Long Beach Harbor in the San Pedro area of the city of Los Angeles. It encompasses approximately one mile of ocean frontage and consists of the land and ocean waters bounded by the mean high tide and the state waters for a distance of 600 feet below low-tide mark, in an area lying between the easterly extension of 40th Street and the southerly extension of Gaffey Street at Point Fermin. Within the boundaries of the Point Fermin Marine Life Refuge abalone, lobster, bonito, rockfish (*Sebastes*), mackerel, perch, kelp bass, sand bass, spotted bass, corbina, croaker, and halibut may be taken by the holders of a valid California sport fishing license. All other fish and forms of aquatic life are protected and may not be taken without a written permit from the Department of Fish and Game.

Farnsworth Bank Ecological Reserve (Fig. II-77)

This reserve is located 1.6 nautical miles southwest of Ben Weston Point on Catalina Island. The offshore bank is composed of sheer rocky pinnacles rising from the ocean floor depths of 250 feet to within 50 feet of the surface. This reserve was set aside to protect the abundant growths of purple coral found there. All fishing, swimming and boating activities are allowed in the reserve waters except that no purple coral may be harvested or removed from the area.

Bolsa Chica Ecological Reserve (Fig. II-77)

This wetland reserve lies inland from Bolsa Chica State Beach and includes an area of 563 acres. Two drill sites for oil lying

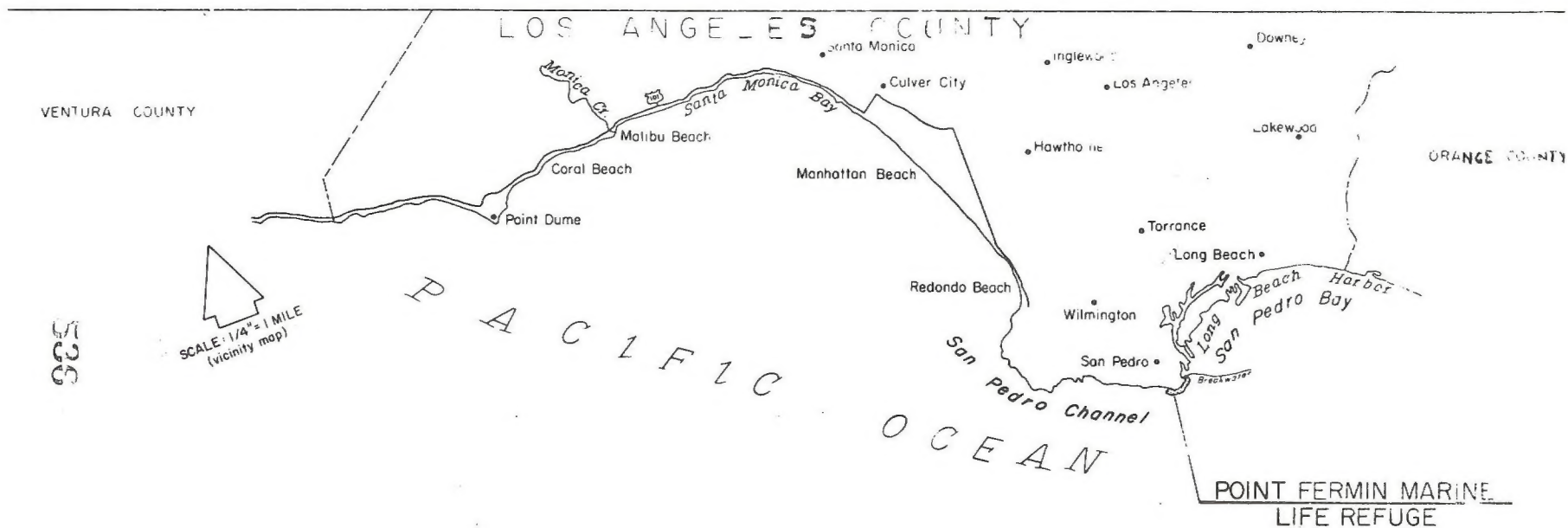


Figure II- 76. From: Smith and Johnson (1972).

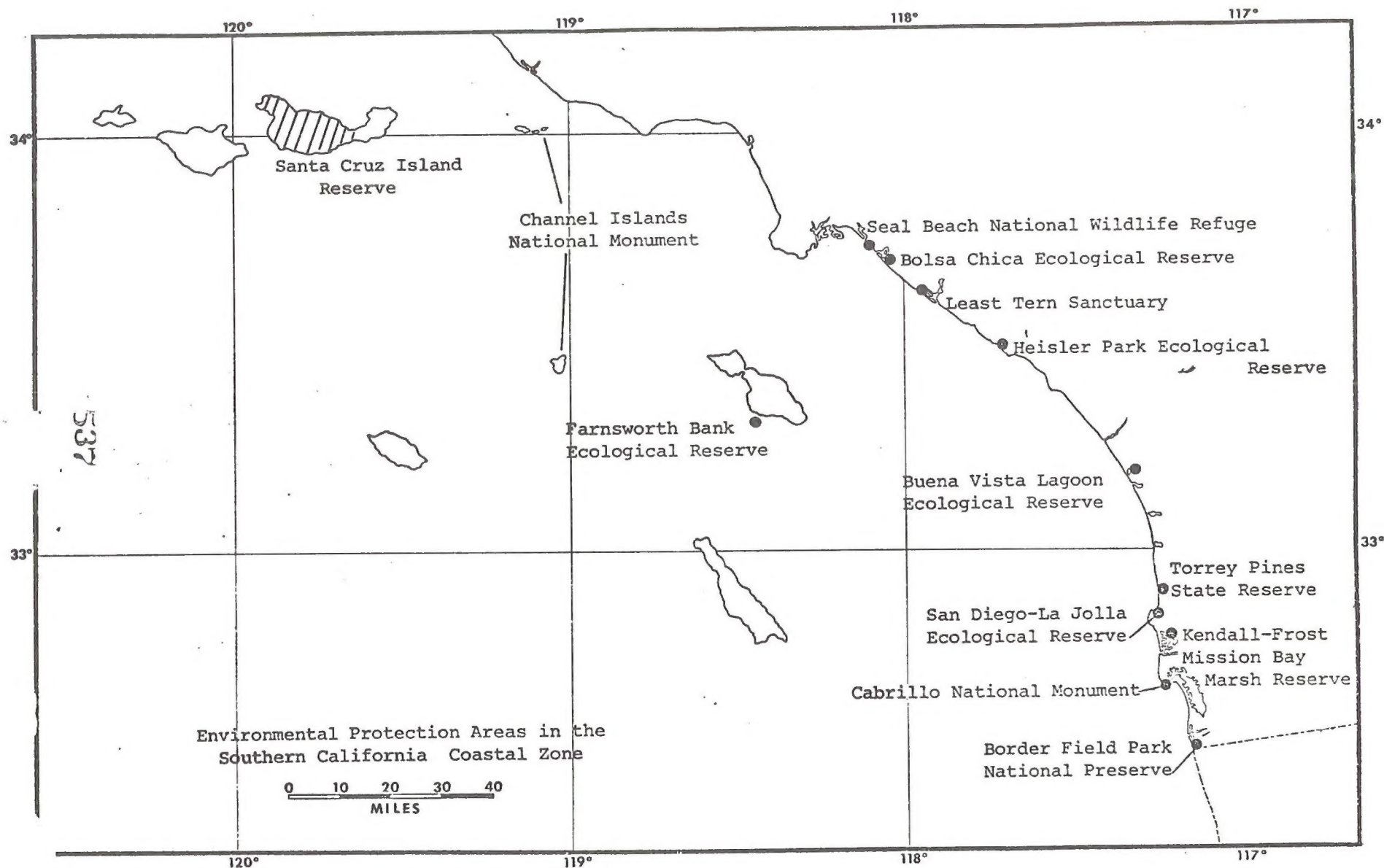


Figure II-77. From: Outwater and Splansky (1974).

within the boundary of the reserve are excluded from the reserve. Special regulations for the area exclude persons other than Department of Fish and Game personnel and Signal Company employees unless they have written permission from the Department of Fish and Game. All fishing is prohibited in the area.

Newport Beach Marine Life Refuge (Fig. II-78)

This marine life refuge is located just south of the entrance to Newport Harbor and encompasses one-half mile of ocean frontage. It includes the land and waters between the line of the mean high tide of the Pacific Ocean and offshore for a distance of 200 feet between the eastern city limit of Newport Beach and Poppy Avenue in the city of Newport Beach.

Irvine Coast Marine Life Refuge (Fig. II-78)

The Irvine Coast Marine Life Refuge is located in the area between the eastern city limit of the city of Newport Beach and the extension of the northwesterly city limit of the city of Laguna Beach. Included in the refuge are the state tidelands along this three and one-half mile stretch of coast and the state waters for a distance of 600 feet offshore from the line of the ordinary high tide.

Laguna Beach Marine Life Refuge (Fig. II-78)

A one and one-half mile stretch of the Orange County coast has been designated as the Laguna Beach Marine Life Refuge. This marine life refuge is bounded on the north by McKnight Drive and on the south by an extension of Aster Street in the city of Laguna Beach and extends from the high tide line out for a distance of 600 feet into the Pacific Ocean.

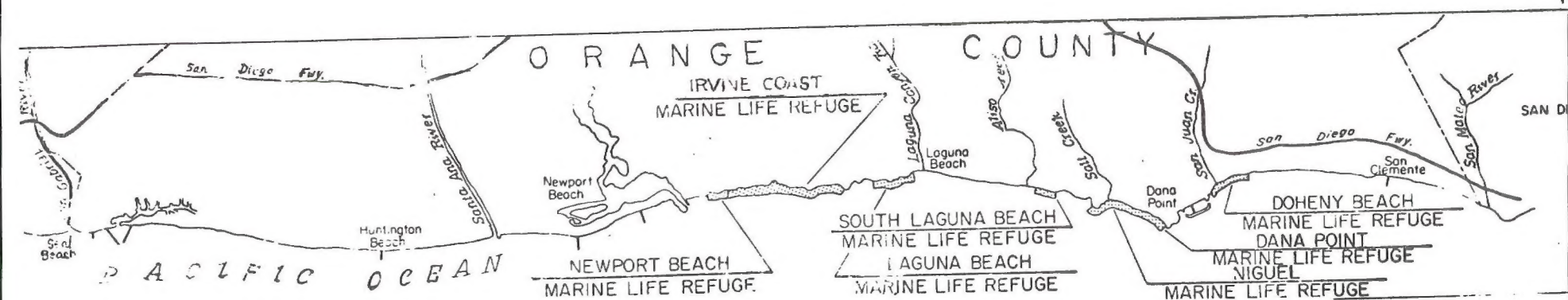


Figure II-78.. From: Smith and Johnson (1972).

Heisler Park Ecological Reserve

This reserve lies within the previously described Laguna Beach Marine Life Refuge. It includes the southeast 800 yards of shoreline and adjacent waters beginning at the westerly boundary of Heisler Park. South Laguna Beach Marine Life Refuge (Fig. II-78)

This marine life refuge encompasses one-half mile of ocean frontage. It includes the area from a point about one-half mile south of Aliso Beach Pier, to an extension of Eagle Rock Way in the city of South Laguna and from the line of the mean high tide 600 feet offshore. Niguel Marine Life Refuge (Fig. II-78)

The Niguel Marine Life Refuge begins on the south edge of Three Arch Bay and continues down the coast along the mean high tide line for a distance of two miles to the north boundary of Dana Point Marine Life Refuge. The refuge includes the waters and submerged lands offshore for a distance of 1,200 feet.

Dana Point Marine Life Refuge (Fig. II-78)

This marine life refuge extends southward for almost one mile from the Niguel Marine Life Refuge to the Dana Point Harbor jetty and includes the waters and submerged lands offshore to a distance of 1,200 feet into the Pacific Ocean.

Doheny Beach Marine Life Refuge (Fig. II-78)

The Doheny Beach Marine Life Refuge begins at the east breakwater of the Dana Point Harbor and extends down the coast along the line of the mean high tide to the easterly boundary of Doheny Beach State Park, a distance of approximately one mile. Also included are the waters and submerged lands offshore to a distance of 600 feet.

Within the boundaries of the Newport Beach, Irvine Coast, Laguna Beach, South Laguna Beach, Niguel, Dana Point and Doheny Beach Marine Life Refuges, the following fish, mollusks and crustaceans may be taken by the holders of a valid California sport fishing license: abalone, lobster, bonito, rockfish (*Sebastes*), mackerel, perch, kelp bass, sand bass, spotted bass, corbina, croaker, and halibut. All other fish and forms of aquatic life are protected and may not be taken without a written permit from the Department of Fish and Game. Within the boundaries of the Heisler Park Ecological Reserve, however, no plant or animal life may be taken without a special permit from the Fish and Game Commission.

Buena Vista Lagoon Ecological Reserve (Fig. II-77)

Buena Vista Lagoon Ecological Reserve is comprised of approximately 71 acres of marsh and lagoon, lying partially within the city limits of Oceanside and Carlsbad. The purpose of the reserve is to preserve one of the few remaining freshwater lagoons left in the Pacific Flyway. In order to preserve the area in as natural a state as possible human activities are limited to designated trails only, and only foot traffic is allowed. No taking of plant or animal life is allowed in the reserve except by permit from the Fish and Game Commission.

San Diego - La Jolla Ecological Reserve (Fig. II-77)

The San Diego - La Jolla Ecological Reserve encompasses one mile of ocean frontage in the La Jolla Bay area of San Diego County. The ecological reserve extends from the most northerly point of Goldfish Point along the line of the mean high tide to a concrete wall lo-

cated approximately 1,000 feet south of the Scripps Institute of Oceanography pier. The reserve includes the water and submerged lands between the high tide line and the intersection of a line drawn in a westerly direction from the concrete wall and a line drawn in a northerly direction from Goldfish Point.

The purpose of the San Diego - La Jolla Ecological Reserve is to preserve in a natural condition the land and waters within the specified boundaries, to protect the aquatic organisms and wildlife found within these boundaries, and to provide a site for public observation and scientific study.

The taking of fish for sport, commercial, or any other purpose is prohibited except by permit from the Fish and Game Commission. Swimming, boating, and other aquatic sports are permitted, if those activities do not harm or disturb marine plants, marine life, geological formations, or archeological artifacts. Boats may be launched and retrieved only in designated areas and may be anchored within the reserve only during daylight hours.

San Diego Marine Life Refuge (Fig. II-77)

This marine life refuge extends from the northern boundary of the San Diego - La Jolla Ecological Reserve up the coast along the line of the mean high tide for a distance of one mile. It also includes the waters and submerged lands offshore for a distance of 1,000 feet. Only licensees of the Regents of the University of California and officers, employees and students of the University are authorized to take, for scientific purposes, invertebrates or specimens of marine plant life without a written permit from the Department of Fish and

Game. In all other cases, these organisms are protected and may not be collected without a written permit from the department.

Areas of Special Biological Significance

The following pertinent factors regarding Areas of Special Biological Significance are quoted from the California Water Resources Control Board Staff Presentation (1973, 1974).

The designation of Areas of Special Biological Significance (ASBS) by the State Water Resources Control Board established a series of areas along the coast of California wherein the state and regional boards maintain natural water quality conditions through applicable legislative authority and administrative measures.

The board adopted the "Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Waters and Enclosed Bays and Estuaries of California" (Temperature Plan) on January 7, 1971, and adopted a revision on October 13, 1971. The Temperature Plan provides specific policy guidance for the State Board and regional boards in the control of waste discharges having a temperature higher than the natural temperature of the receiving water. The plan includes a provision which requires new discharges of heated waste being discharged to coastal waters to be a sufficient distance from ASBS to assure the maintenance of natural temperature in these areas. No provisions are included for ASBS in enclosed bays or estuaries at this time.

The Board adopted the "Water Quality Control Plan for Ocean Waters of California" (Ocean Plan) on July 6, 1972. The Ocean Plan includes a provision requiring that the location of waste discharges must be de-

terminated after a detailed assessment of oceanographic characteristics and current patterns to assure that natural water quality conditions are not altered in areas designated as being of a special biological significance. The plan also provides that wastes shall be discharged a sufficient distance from ASBS to assure maintenance of natural water quality conditions in such areas.

The Temperature Plan and the Ocean Plan were accepted by the Federal Environmental Protection Agency as part of the state-federal water quality standards on August 18, 1972.

The primary purpose of designating ASBS is to guide the State and Regional Boards in decisions relating to the control of waste discharges to coastal waters. Ordinarily control will be exercised in the establishment of waste discharge requirements as authorized by the Porter-Cologne Act (Section 13260 Water Code), and the issuance of permits as required by the Federal Water Pollution Control Act of 1965 and its amendments of 1972 (Section 402, PL 92-500).

Generally, the Regional Boards would prohibit the direct discharge of wastes into an ASBS or in the immediate vicinity. Discharges some distance away are required to have a monitoring program to demonstrate that the discharge could not be detected inside the ASBS. Wastes presently being discharged into ASBS are phased out. Existing discharges which influence water quality in ASBS are either phased out or required to comply with requirements which prevent the detection of waste substances within ASBS.

The Ocean Plan is not applicable to vessel wastes, the control of dredging, or the disposal of dredging spoil. Therefore, the discharge of

wastes from boats and dredging activities in ASBS would not be affected by such designation.

"Areas of special biological significance are those areas containing biological communities of such extraordinary, even though unquantifiable value, that no acceptable risk of change in their environments as a result of man's activities can be entertained."

The procedures contained additional guidelines regarding the applicability of the concept of ASBS and the impact of the designation. Specific procedures were included for the development of recommendations to the State Board by the Regional Boards. These procedures required the Regional Boards to conduct public hearings to receive testimony on the specific recommendations of their staff, and to forward the Regional Board recommendation to the State Board for designation of specific areas. The recommendation was to be accompanied by a copy of the staff report, a summary of the hearing, and a detailed justification supported by evidence presented at the hearing for each recommended area.

The use of criteria developed by the staff for screening purposes may require additional explanation:

Criterion 1. Candidate areas are located in ocean waters as defined in the "Temperature Plan" and the "Ocean Plan."

Several areas off the mouths of streams were recommended because of their importance as pathways for the migration of anadromous fish. Although the area could be regarded as within ocean waters, the areas could also fit the definition of estuaries in the Temperature Plan, i.e. ".... Estuarine waters will generally be considered to extend from a bay or the open ocean to the upstream limit of tidal action, but may be considered

to extend seaward if significant mixing of fresh and saltwater occurs in the open coastal waters....." Unless definite guidance was provided by the Regional Board staff to assist in making a determination, the proposed area was not included in the list of qualified areas.

Criterion 2. Candidate areas are intrinsically valuable or have recognized value to man for scientific study, commercial use, recreation use, or esthetic reasons .

Supporting information for recommended areas was reviewed to determine if the biological community had some inherent value which made the area deserving of special protection from adverse water quality conditions, or whether the area was popular because of its accessibility, scenic values, or use as a desirable recreation area. In other words, the presence of a special biological community was a fundamental requirement for consideration. In addition, the biological community was not identified as special unless it was shown to require the extreme protection afforded by the ASBS designation. As an example, rocky islands known as nesting or roosting sites by large numbers of birds could not be accepted as special unless there was evidence that the birds or other aquatic organisms in the area were part of a fragile biological community which was dependent on natural water quality conditions. Some areas were recommended because they were marine life refuges or ecological reserves created by the legislature or by actions of the Fish and Game Commission. Ecological reserves were accepted for consideration by the Board without substantial supporting evidence because they are established for the purpose of protecting rare or endangered wildlife or aquatic organisms, or specialized habitat types. Marine refuges were not accepted for consideration by the

Board unless evidence was supplied to show that they contained a special biological community which required protection within the designation of ASBS. In some cases, marine life refuges were established primarily to regulate the take or harvest of wildlife or aquatic life, rather than to protect a habitat or biological community.

Criterion 3. Candidate areas need protection beyond that offered by waste discharge restrictions or other administrative and statutory mechanisms.

Regional Boards have authority to prohibit waste discharges to specific waters for the protection of beneficial uses (Section 13243, Water Code) as part of an adopted regional water quality control plan. Waste discharge requirement can limit: (1) the type of waste; (2) the location, time and conditions of discharge; (3) and the concentration of waste constituents in the effluent and in the receiving waters. Thus the controls already available for the protection of biological communities are considerable, and should be adequate in all but unique situations.

The special protection given by designation of ASBS is that risk of damage will be eliminated to a greater degree than if discharges were permitted in the vicinity of the biological communities. The presence of discharges establishes a risk due to malfunctions, disasters, or carelessness. There may also be some risk as a result of establishing concentrations of waste constituents which are considered to be safe with the present incomplete state of knowledge.

Recommended areas were not included for State Board consideration unless some effort had been made to provide evidence that this special degree of water quality protection was necessary for continued mainten-

ance of the biological community.

Criterion 4. Candidate areas must have faced public review through hearings on their consideration as an ASBS.

The Areas of Special Biological Significance in Southern California are listed below:

San Miguel, Santa Rosa and Santa Cruz Islands
San Nicolas Island and Begg Rock
Santa Barbara and Anacapa Island
San Clemente Island
Catalina Island, including the following subareas:

- Subarea #1 Isthmus Cove
- Subarea #2 North end of Little Harbor to Ben Weston Point
- Subarea #3 Farnsworth Bank
- Subarea #4 Binnacle Rock to Jewfish Point

Mugu Lagoon to Latigo Point
Heisler Park Ecological Preserve
Newport Beach Marine Life Refuge
Irvine Coast Marine Life Refuge
San Diego-La Jolla Ecological Reserve
San Diego Marine Life Refuge

The California Coastal Zone Conservation Commission (1975) mentions ASBS in considerations of their coastal plan.

Unique Marine Biological Assemblages

The only area where the purple coral, *Allopora californica*, forms dense concentrated populations in Southern California is on Farnsworth Bank off Santa Catalina Island (Marine Life Refuge Overlay). Its occurrence is only spotty on the rest of the study area.

The Echiuroid Worm *Listriolobus pelodes* occurs at other areas along the Southern California coast, but is heavily concentrated only in the fine sediment area near Santa Barbara (Allan Hancock Foundation, 1965).

6. Rare and Endangered Species

In 1970, in cooperation with the federal government, the California Department of Fish and Game formulated a list of the state's rare and endangered species. Since 1901, game species have had some form of management and protection to assure continued propagation and relative abundance. What was lacking was protection for California's nongame fish and wildlife. The California Department of Fish and Game (1974) declared 49 species of wildlife to be threatened with extinction or endangerment. According to the above report, there are 7 endangered and 3 rare species in the Southern California area. This list covers all freshwater fish, land birds and terrestrial wildlife. Because of the difficulty of accurate monitoring, the marine species have not been placed on this list. Impacts on endangered species may be found in Section III.D.7.

The U.S. Fish and Wildlife Service (1974) has placed 8 species of whales on the endangered list. Seven of these species (Table II-48) occur in the Pacific waters off Southern California, but the gray whale is the only species which migrates extensively within the island area, although humpback whales are abundant during the winter around rocks off San Miguel, San Nicolas and San Clemente Islands.

Unless otherwise stated, information for the following comes from the California Department of Fish and Game (1974).

The legislation concerning rare and endangered species is given below.

The Intent of the Legislature....

Fish and Game Code

Article 1. California Species Preservation

900. The intent of the Legislature and the purpose of this article is to preserve, protect and enhance the birds, mammals, fish, amphibia, and reptiles of this state.
(Added by Stats. 1970, Ch. 1036.)

901. The department shall establish criteria for determining if a species or subspecies of bird, mammal, fish, amphibia or reptile is endangered or rare. A species is endangered when its prospects of survival and reproduction are in immediate jeopardy. A species or subspecies is rare when it may become endangered if its present environment worsens.
(Added by Stats. 1970, Ch. 1036.)

902. The department shall inventory the birds, mammals, fish, amphibia, and reptiles of the state which are threatened biennially. Such inventory shall include, but is not limited to: (a) An enumeration of the threatened birds, mammals, fish, amphibia and reptiles of the state. (b) A determination of the condition of each species with respect to its being endangered or rare, or becoming endangered or rare.
(Added by Stats. 1970, Ch. 1036.)

903. The department shall submit to the Governor and the Legislature biennially, not later than January 1, the first of which shall be submitted no later than January 1, 1972, a full and accurate report of the inventory, including recommendations for: (a) The addition or deletion of endangered and rare species under the fully protected category where necessary. (b) Preserving, protecting, and enhancing the conditions of endangered and rare species of the state.
(Added by Stats. 1970, Ch. 1036.)

Chapter 1.5. Endangered Species

2050. The Legislature finds that many species and subspecies of birds, mammals, fish, amphibia, and reptiles are endangered because their habitats are threatened with destruction, drastic modification, or severe curtailment, or because of commercial exploitation through exports and imports of birds, mammals, fish, amphibia, and reptiles, or by other means, or because of disease, predation, or other factors.
(Added by Stats. 1970, Ch. 1510.)

2051. These definitions govern the construction of this chapter:

(a) "Endangered animal" is an animal of a species or subspecies of birds, mammals, fish, amphibia, or reptiles, the prospects of survival and reproduction of which are in immediate jeopardy from one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease.

(b) "Rare animal" is an animal of a species or subspecies of birds, mammals, fish, amphibia or reptiles that, although not presently threatened with extinction, is in such small numbers throughout its range that it may be endangered if its environment worsens.

(Added by Stats. 1970, Ch. 1510.)

2052. No person shall import into this state, or take, possess, or sell within this state, any bird, mammal, fish, amphibia or reptile, or any part or product thereof, that the commission determines to be an endangered animal or rare animal, except as otherwise provided in this chapter.

(Added by Stats. 1970, Ch. 1510.)

In addition, the Federal government enacted the Endangered Species Act in 1973, which sets forth strict regulations covering all species listed on the official "Endangered Fauna List" compiled by the U.S. Fish and Wildlife Service, 1974.

Table - II-48

WHALES IN THE STUDY AREA LISTED AS ENDANGERED
BY THE U. S. FISH AND WILDLIFE SERVICE (1974)

Gray Whale	- <i>Eschrichtius gibbosus</i>
Blue Whale	- <i>Balaenoptera musculus</i>
Finback Whale	- <i>Balaenoptera physalus</i>
Sei Whale	- <i>Balaenoptera borealis</i>
Humpback Whale	- <i>Megaptera novaeangliae</i>
Pacific Right Whale	- <i>Balaena glacialis</i>
Sperm Whale	- <i>Physeter catodon</i>

a. Endangered Species

1. CALIFORNIA BROWN PELICAN (*Pelecanus occidentalis californicus*)

According to Gress (1970) the continued existence of the brown pelican in California is in peril. Though still commonly seen in bays and lagoons along the Pacific Coast from June through January, there has been a great decline of successful breeding in recent years. Because pelicans are long-lived and range extensively after the breeding season, a decrease in their numbers has not been apparent. Thus documentation of reproductive failures did not occur until several years after the symptoms probably first existed.

Brown pelicans wander extensively along the coast between nesting seasons, with the movement north occurring primarily in June and July. The pelican's "wintering" range extends as far north as southern British Columbia (Vancouver Island) and south along the west coast of Mexico to Colima.

The current breeding range of *P. o. californicus* extends from the Channel Islands (principally Anacapa Island), occasionally north to Bird Island off point Lobos, Monterey County, California, and south, including the several islands along the coast of Baja California and in the Gulf of California, to Isabel Island and the Tres Marias Islands off Nayarit, Mexico. Nest building and breeding occurs during spring and summer. In surveys of other historical breeding sites in California (Santa Barbara Island, San Miguel Island, Santa Cruz Island and Point Lobos) no attempted nesting was seen or reported in 1970. Anacapa Island was the only remaining nesting area in California, but breeding is unsuccessful even here.

-
1. Listed as Endangered by the U.S. Fish & Wildlife Service, May 1974.
 2. Listed by the California Dept. of Fish & Game, 1974.

To summarize brown pelican breeding on Anacapa Island for the 1970 breeding season, out of 127 nesting attempts in the first colony and 425 in the second colony (total = 552), only one chick hatched. Thus a repeat of the 1969 disaster with the same reproductive failures caused by the collapse of thin-shelled eggs had occurred in 1970. Gress concluded the brown pelican is presently incapable of reproducing in California.

According to the California Department of Fish and Game (1974) a 1972 survey indicated that the total population approximates 100,000 birds with 20,000 pelicans frequenting California's coast from August through November. California's only remaining nesting colony on Anacapa Island, numbering 300 pairs, is currently incapable of maintaining itself. Reproductive failure is due to collapse of thin-shelled eggs during incubation, attributed to the effects of pollutants on breeding birds. In 1971 only 7 young were produced in 600 nesting attempts. Encouragingly, reproduction in 1972 and 1973 were 57 and 34 young respectively. A portion of the Anacapa Island colony nested on an islet adjacent to Santa Cruz Island in 1972.

High concentrations of DDT in pelican tissues obtained from their natural diet of fish are the apparent cause of the thin-shelled eggs.

ii. SOUTHERN BALD EAGLE (*Haliaeetus leucocephalus leucocephalus*)^{1,2}

DISTRIBUTION: This is the only eagle restricted to North America. Occurs statewide, particularly along the coast and in interior California about large lakes, reservoirs, and wetlands. Nests in the vicinity of large lakes and reservoirs from Fresno County north.

STATUS: Endangered. Historically, bald eagles nested in abundance on

the Channel Islands and along the coast; present nesting is limited to the Sierra Nevada, Cascade, and Klamath mountains. Thirty one territories were occupied in California in 1943, when 19 pairs produced 24 young. An influx of northern birds is evident in winter months. Reasons for its decline include irresponsible shooting, removal of nest trees, human encroachment into nesting and feeding areas, power line electrocution, environmental pollution, and contamination of the food chain by persistent pesticides.

No bald eagles remain in Southern California near the coast. The nearest nest is by Lake Matthews, approximately 40 miles inland and on the eastern side of the Santa Ana Mountains (Howard Leach, personal communication 1974).

iii. CALIFORNIA CONDOR (*Gymnogyps californianus*)^{1, 2}

A huge black vulture with white underwing patch and bare orange head. It is North American's largest land bird and has a wingspan of over nine feet (2.7m).

DISTRIBUTION: A relic of the Ice Age, the California condor once ranged over much of Western North America from British Columbia to Baja California. Its numbers are now (1972) reduced to slightly more than 50 birds confined largely to the rugged mountains of Ventura and Santa Barbara counties. Recent reports of a California condor in Baja California require further confirmation.

STATUS: Endangered. Population is declining because of low recruitment of young, habitat loss, and human disturbance. Condors do not breed until 5-6 years old, females lay but one egg every two years, and incubation and brooding require six months.

According to Howard Leach (personal communication, 1974) the condor had only 15 nests in Santa Barbara and Ventura Counties during 1972.

iv. AMERICAN PEREGRINE FALCON (*Falco peregrinus anatum*)^{1, 2}

DISTRIBUTION: The American peregrine, extinct as a breeding bird east of the Rocky Mountains breeds in California along the coast, channel islands, and in higher mountains inland. In the 1940s the breeding bird population was 100 pairs; in 1970 this population had declined to 10 birds, of which 2 pairs produced 4 young.

STATUS: Endangered. Mortality exceeds recruitment. Food chain contamination by persistent pesticides and other contaminants, illegal taking by falconers, human disturbance, and occasional shooting are contributing to its decline.

Number of this subspecies in captivity unknown.

v. LIGHT-FOOTED CLAPPER RAIL (*Rallus longirostris levipes*)^{1, 2}

DISTRIBUTION: This is the only subspecies of clapper rail found in Southern California coastal salt marshes. It ranges from Santa Barbara south to San Quentin Bay, Baja California. Breeding colonies in California are limited currently to Anaheim Bay, Upper Newport Bay, Los Penasquitos Lagoon, Tijuana River Marsh, and remnant salt marshes in Mission and San Diego Bays.

STATUS: Endangered. A freeway through Anaheim Bay and planned developments of Tijuana River Marsh, south San Diego Bay, Mission Bay, Upper Newport Bay, Los Penasquitos Lagoon, and other Southern California coastal salt marshes (See Errata sheet for graphic 3) threaten continued survival of the light-footed clapper rail.

The clapper rail utilizes both fresh water and salt marsh environments for nesting and feeding. Its food consists of clams, crabs, and other invertebrates of the marshes (Sandy Wilber, personal communication).

vi. CALIFORNIA LEAST TERN (*Sterna albifrons browni*)^{1, 2}

DISTRIBUTION: Summer visitor from April through September along the coastline from Mexico to San Francisco. Winters in the southern hemisphere and breeds along the Pacific Coast from Baja California to San Francisco Bay.

STATUS: The California Least Tern once nested in uncounted thousands on the beaches and near the estuaries of the Pacific coast of North America, from Monterey Bay south of San Francisco to Scammons Lagoon in Baja California. Within the last century, these flocks have dwindled rapidly, until in 1971 the remaining population in California was estimated at less than 300 pairs (Bender, 1973). The decline has been caused by human appropriation of the nesting grounds for recreation and housing sites and destruction of the estuarine feeding areas by dredging and pollution. The degree of disturbance and impending development of the remaining breeding areas resulted in the subspecies' placement on the endangered species lists of both the U. S. Department of the Interior and the state of California (Bender, 1973). Unlike the clapper rail, the least tern uses estuaries only for feeding, and nests on sandy beaches.

According to the California Department of Fish and Game (1974) successful nesting requires sandy beaches free from human disturbance and vegetation. The U. S. Marine Corps has a program of protection and enhancement of this subspecies, and has demonstrated that measures can

be taken to encourage Least Tern production: the Santa Margarita River colony at Camp Pendleton increased from 19 pairs in 1970 to 250 nesting pairs in 1973. In 1973, a total of 624 pairs nested in 19 sites located mostly on Southern California beaches.

Bender (1973) reported 583 nesting pairs at 17 sites south of Point Conception. The location of the nests and number of nesting pairs are shown on Table II-49.

vii. BELDING'S SAVANNAH SPARROW (*Passerculus sandwichensis beldingi*)²

DISTRIBUTION: The Belding's savannah sparrow occurs as a resident in the tidal estuaries of Southern California and Baja California, Mexico. It is closely associated with the pickleweed habitat occupied by the endangered light-footed clapper rail. Surveys made in 1973 revealed that only 11 breeding sites exist from Santa Barbara to San Diego (Fig. II-79).

STATUS: Endangered (New to list.) Planned developments of Tijuana River Marsh, Los Penasquitos Lagoon, and other Southern California coastal salt marshes threaten its survival. The breeding population is about 1,100 pairs.

viii. UNARMORED THREESPINE STICKLEBACK (*Gasterosteus aculeatus williamsoni*)^{1, 2}

DISTRIBUTION: The unarmored form still persists in Soledad Canyon in the upper Santa Clara River drainage, Los Angeles County. It has probably hybridized with *G. a. microcephalus* in other areas where it was present.

STATUS: Endangered. Populations from the Los Angeles Basin Streams (Los Angeles, San Gabriel, Santa Rivers) have been exterminated. The

Table II-49 (Bender, 1973)
CALIFORNIA LEAST TERN NESTING SITES AND
POPULATION IN 1973 1/

<u>Site</u>	<u>No. Pairs</u>	<u>No. Nests</u>	<u>No. Chicks</u>	<u>No. Immatures</u>
Alameda County				
Bay Farm Island	1	---	---	---
Oakland Airport	40	---	---	67
Ventura County				
Point Pinos	7	---	---	---
Los Angeles County				
Playa del Rey	20	11	3	14
San Gabriel River	25	12	4	14
Orange County				
Huntington Harbour	25	49	21	17
Huntington State Beach	16	16	5	1
San Diego County				
Santa Margarita River	250	315	467	---
Buena Vista Lagoon	2	0	0	0
Agua Hedionda Lagoon	6	5	0	0
Batiquitos Lagoon	30	22	17	14
San Elijo Lagoon	1	0	0	0
Del Mar	4	1	0	0
Los Penasquitos Lagoon	15	6	---	---
Mission Bay (all sites)	72	97	---	---
San Diego Airport	50	68	11	16
Sweetwater River	20	4	---	11
So. San Diego Bay	35	24	14	5
Tijuana River	<u>5</u>	<u>7</u>	<u>4</u>	<u>3</u>
Total Recorded	624	637	546	162

1/ Numbers of nesting pairs are conservative estimates; numbers of nests, chicks and immatures are actual counts and are, therefore, minimum figures. Unknown information is indicated by a dash.



Figure II-79. Breeding sites of Belding's savannah sparrow (California Department of Fish and Game, 1974).

population in the Santa Clara River is threatened by increased recreational use and development in Soledad Canyon.

The U. S. Fish and Wildlife Service also considers the Santa Barbara song sparrow *Melospiza melodia graminea* to be an endangered species. However, Hunt and Hunt (1974) did not see this species during their study of Santa Barbara Island and presumed the endemic subspecies is extinct.

b. Rare Species

i. Island Fox (*Urocyon lottorallis*)²

The island fox is endemic to the islands off Southern California and, according to the report from the intensive study conducted by Laughrin (1973), appeared to have normal healthy populations except on Santa Catalina Island where it may be endangered.

Table II-50 shows the estimated population of the island fox per square mile. The higher population densities found for Santa Cruz are probably real differences from the other islands. The chaparral-woodland-grassland vegetation on Santa Cruz is probably an optimum habitat type for the fox in terms of food availability. Habitats of Santa Cruz that are similar to those of the other islands (except Santa Catalina) are expected to have comparable fox densities. The island fox is an omnivore (eats both plants and animals).

An example of the correlation between fox abundance and habitat productivity was revealed from data of the Santa Rosa population. Two habitat types were sampled. One was basically a one-layered in structure dominated by annual grasses and perennial forbs, usually less than two

Table II-50 (From: Laughrin, 1973).

Island Fox Trapping Results

<u>Island</u>	<u>Number of trap- periods</u>	<u>Total captures of foxes</u>	<u>Total individual foxes captured</u>	<u>Mean trap- period efficiency (%)</u>	<u>Density estimate (fox/mi.²)</u>
San Miguel	45	18	18	43	7
Santa Rosa	120	43	34	50	11
Santa Cruz	426	195	115	72	33
San Nicolas	40	24	24	72	7
Santa Catalina	60	2	2	6	0.3
San Clemente	384	150	103	52	11

feet in height, and grazed by cattle. Taller shrubs were sometimes present either in gullies and canyon bottoms or were widely scattered on uplands and were not a significant part of the cover. This situation was almost certainly low in productivity of appropriate vegetative material for fox consumption. Insect availability may have been lower here too. Fox density was about 6 animals per square mile. In contrast, a second area with a greater plant species diversity was sampled on the eastern side of the island where the density was estimated to be 15 foxes per square mile. This more complex vegetative association was grouped into three layers: grasslands and forbs (0-1'), perennial woody shrubs (1-6'), and trees (6-20'). Presence of the middle layer of fruiting shrubs is probably the important addition as it includes much of the vegetation aspect of the fox's diet while the total increased diversity increases the insect availability.

All the islands had some woodland-bushland vegetation, but Santa Cruz had large portions of its northern part where this vegetation predominated. Santa Catalina Island also has large areas of Woodland-bushland vegetation, and Laughrin is not sure why this island has low population densities.

ii. GUADALUPE FUR SEAL (*Arctocephalus philippii townsend*)²

DISTRIBUTION: It occurred historically from the Farallon Islands west of San Francisco, south to San Benito Island, Lower California, Mexico. It was last reported in California waters in 1949 when one was observed on San Nicolas Island.

STATUS: Rare. A breeding colony on Guadalupe Island, Mexico, is slowly

increasing in numbers. Human disturbance and illegal shooting is responsible for the slow recovery of this species. The population numbered 600 in 1965.

Dailey (1974) cited DeLong (personal communication) who reported sightings of a few visitant males at San Miguel Island each year between 1969-1973.

iii. CALIFORNIA BLACK RAIL (*Laterallus jamaicensis coturniculus*)²

This is a sparrow-sized blackish rail with a small black bill, white-speckled back, and white bars on its sides.

DISTRIBUTION: Historically it occurred in limited numbers in salt marshes from Tomales Bay south to Lower California, and in inland freshwater marshes, including portions of the Colorado River. Known to nest in recent years only along the Colorado River from Laguna to Imperial dams and at West Pond, Imperial County.

STATUS: Rare. Because of its secretiveness and small numbers it is only rarely seen. Destruction of coastal and inland wetlands by filling and draining threatens habitat vital to its existence. Its current distribution and numbers are as yet undetermined.

The Guadalupe fur seal and California black rail are listed as threatened species by the U. S. Bureau of Sport Fisheries and Wildlife (1973). As mentioned by Dailey (1974) the sea otter used to occur along the Southern California coast, but presently does not occur south of Morrow Bay.

G. Human Utilization

1. Land Use

Land use along the Southern California coastal zone is generally classified as urban in nature. Because of the topographical features of the region, the urban growth areas are separated by ranges of low mountains, marshes, or other physical characteristics which lend to highly developed areas suited to the geography. Agricultural uses are located within the fertile valley areas which are suited for irrigation systems or for dry land operation. The transportation systems are situated within the region by virtue of the geographical and physical characteristics, and therefore, set the pattern for urban growth. The coastline is characterized by bays and harbors, both natural and man made, which foster water orientated recreation and living. Military uses are scattered throughout the region both on the coast and inland. The major population centers are in the Los Angeles, Long Beach, Anaheim, Santa Ana, Garden Grove, San Diego, Riverside, San Bernardino, Ontario, the Oxnard, Simi Valley, Ventura Standard Metropolitan Statistical Areas, and in the Santa Barbara area of Santa Barbara County.

The 1970 census of population records the population of the various counties as:

<u>County</u>	<u>Population by County</u>	
	1970 <u>Population</u>	1960-1970 Change %
Santa Barbara	264,324	56.4
Ventura	376,430	90.1
Los Angeles	7,036,463	16.6

Orange	1,420,386	101.8
San Diego	1,357,782	31.4
Riverside	459,074	49.9
San Bernardino	681,092	35.5

Source: U.S. Census of Population, 1970.

Land use by category for each county is shown in Table II-51. The reporting categories are broad in scope, but present the developmental form and structures of the urban and non urban uses. The category "other" includes non urban areas, many of them mountainous. For example, vacant, undeveloped, rural recreation and livestock areas are found in each county, but are not necessarily important to the study area. The small portion of Santa Barbara County south of Point Conception is not included since the data has not been segregated from the county totals, nor is that section of the coast situated directly within the study area.

The spatial distribution of the urban uses and the major agricultural uses is shown in Figure II-80. The urban enclaves near the coast are designated by crosshatches. The major concentration is in the southern portion of Los Angeles County with extensions overlapping into San Bernardino, Riverside, and Orange Counties. The next largest concentration is found in the San Diego urban area which extends from the coast to the eastern valleys. Other large urban groupings are found in the Oxnard, Ventura, and Santa Barbara areas.

Major agricultural areas are shown within the dotted boundaries. The major groupings are located within Ventura, San Bernardino, and Riverside Counties, with other large areas located in the remaining coun-

Table II-51
Land Use by County

	By Acres 1970					
	<u>San Diego</u>	<u>Orange</u>	<u>Los Angeles</u>	<u>River- side</u>	<u>San Bernardino</u>	<u>Ventura</u>
Residential	68,448	100,763	417,764	28,820	41,910	21,790
Commercial	7,104	12,301	41,648	3,920	6,640	2,890
Industrial	6,899	12,552	79,305	760	1,450	540
Other urban *	429,075	45,179	263,195	8,860	9,000	4,530
Agriculture	209,311	53,210	98,956	178,920	87,810	120,120
Other**	2,028,805	287,045	1,798,255	569,190	488,870	1,030,100

Only includes those portions of the county within the area of consideration.

*Contains urban uses not elsewhere classified, such as public, Semi public, recreation, military, communications, transportation, utilities etc.

**Contains all non urban uses such as vacant, undeveloped, livestock areas, rural recreation etc.

Source: State of California Department of Water Resources
Southern California Association of Government
Los Angeles County Planning Department
Orange County Planning Department
San Diego County Planning Department
San Diego Comprehensive Planning Organization
Riverside County Planning Department
San Bernardino County Planning Department

ties.

The transportation network within the region is typical of the established pattern found in a rapidly growing urban area in which no rapid transit system exists. As a result of private automobile use, there are numerous freeways providing intra and inter station access facilities in addition to routes for through traffic.

The main north-south Interstate is 5 (Santa Ana Freeway) which runs from the Mexican border northerly to the San Joaquin Valley. US 101 (Pacific Coast Highway) travels northwesterly from the Los Angeles area to the study area boundary in Santa Barbara county then proceeds northerly to the Bay area. The Interstate 15/U.S. 395 provides north-south access from San Diego to the high desert valley to the north. Other north-south freeways within the Los Angeles area include Interstate 605, 405, State 7, and 11. The major east-west facilities include Interstate 8 from San Diego, Interstate 10 from Los Angeles, plus several U. S. and State Highways. The total arterial system is augmented by other state, county, and local systems.

The railway system is composed of passenger and freight systems. The major passenger network operated by Amtrack covers the coastal route from San Diego to the Bay area, Los Angeles to the New Orleans areas, and from Los Angeles to Kansas City. There are numerous freight lines running throughout the whole area.

The airport system, both commercial and military, is dispersed widely within the study area. The major airports are located in San Diego and Los Angeles, with smaller commercial facilities in Burbank, Ontario, Santa Ana, and Long Beach. Lesser airports, both private and

public, for private aircraft are well dispersed within the region. Military air bases or air stations are also found in the region with a preponderance located in the San Diego area.

Electric generating stations, and transmission lines, are interconnected and well dispersed throughout the total region. The major private suppliers are San Diego Gas & Electric Company and Southern California Edison Company. Numerous publicly owned and cooperatively organized utility companies also provide service with the area.

The net operating capability KW of the larger systems are shown below:

<u>Unit</u>	<u>Net Operating Capability KW</u>
San Diego Gas & Electric	1,283,850
Southern California Edison Co.	8,727,915
Escondido Mutual Water Co.	760
City of Burbank	169,000
City of Glendale	158,000
City of Los Angeles	3,171,725
City of Pasadena	233,400

Source: California Public Utilities Commission

The principal natural gas transmission and distribution trunk lines, according to the California Public Utilities Commission include those operated by:

Southern Counties Gas Company of California
Southern California Gas Company
Pacific Lighting Gas Supply Company

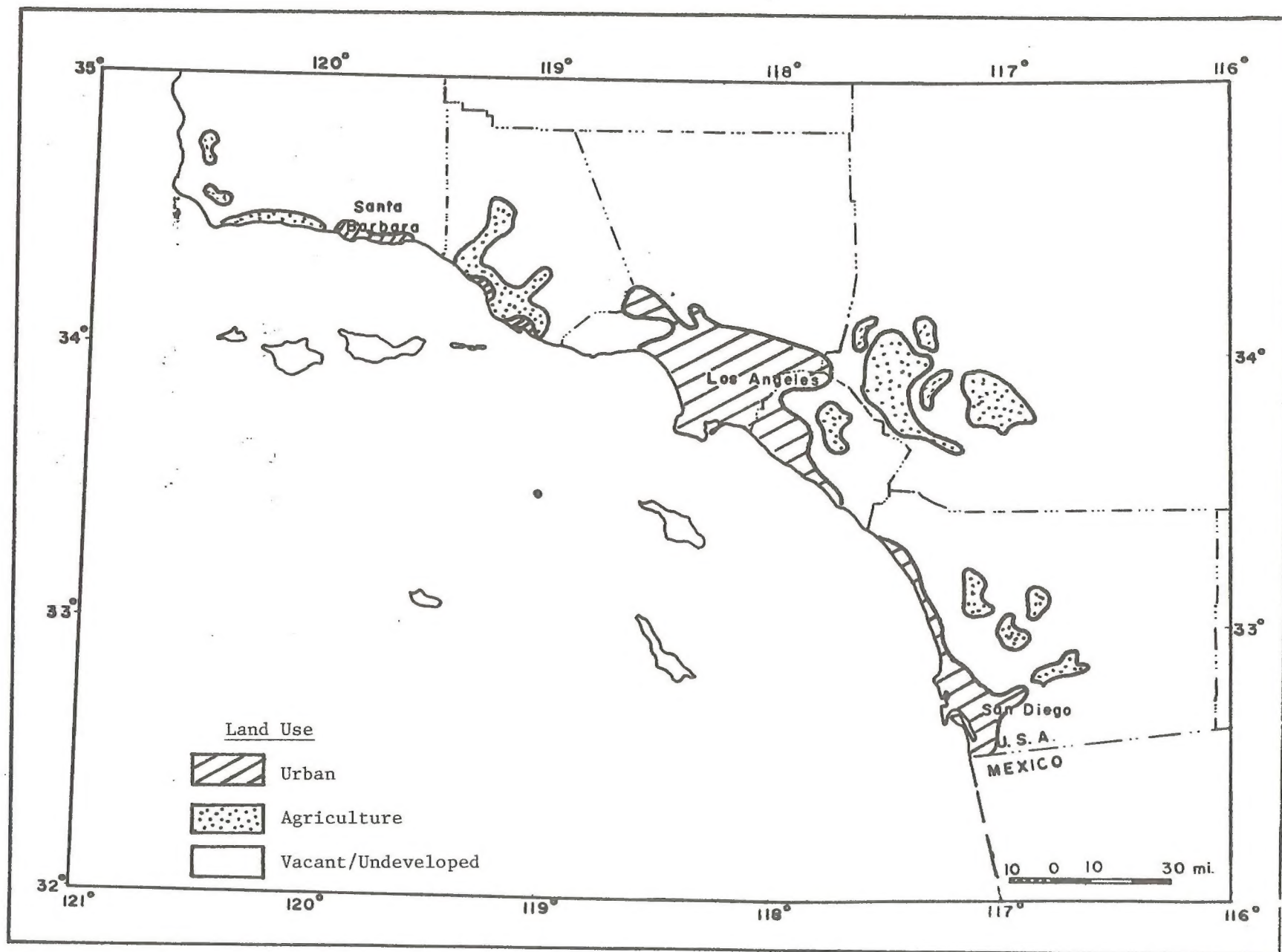


Figure II-80

San Diego Gas & Electric Company

City of Long Beach

Atlantic Richfield Oil Corporation & Subsidiaries

Standard Oil Company of California

Southern California Edison Company

The natural gas systems are dispersed throughout the region with just a few systems covering the major place of operations. A complex network exists in the Los Angeles metropolitan area where many systems are intermingled and are connected to the major transmission and distribution trunk lines.

The American Petroleum Institute published a map in January 1971 showing products pipe lines for the United States and Southern Canada. Several pipe lines are shown within the study area with the majority feeding into and out of the Los Angeles area. The major lines include a Shell Oil 4", 6" line connecting Los Angeles to Ventura County; Mobil Oil 6"-8" lines extending into the San Fernando area; the San Diego Pipeline, 11" connecting the Southern Pacific line at Norwalk; the Southern Pacific 16" line extending from Los Angeles to the east with 6" feeder to March A.F.B. and Norton A.F.B. The California-Nevada line, 8"-14 extends northerly from the Colton area. Several company lines within the Los Angeles area are owned by Shell Oil, Mobil Oil, Arco, Philips Oil, Union Oil, Standard Oil, and Gulf Oil.

The American Petroleum Institute map also lists the refineries within the study area and their respective capacities. The list is shown below in Table II-52.

Table II-52

STUDY AREA REFINERIES AND CAPACITIES
(Barrels per day)

<u>Company</u>	<u>Location</u>	<u>Capacity</u>
Atlantic Richfield	Carson	165,000
Champlin Petroleum Co.	Wilmington	30,000
Carson Oil Company	Torrance	7,000
Douglas Oil Company	Paramount	25,000
Edgington Oil Inc.	Long Beach	15,000
Edgington Oil Inc.	Oxnard	2,500
Fletcher Oil Co.	Carson	12,000
Gulf Oil Corp.	Santa Fe Springs	49,800
Lunday-Thagard Oil Co.	South Gate	36,00
Macmillan Ring-Free Oil Co	Signal Hill	10,000
Mobil Oil Corp.	Torrance	123,500
Newhall Refining Co.	Newhall	6,500
Powering Oil Co.	Santa Fe Springs	28,500
Shell Oil Co.	Wilmington	86,000
Standard Oil Co.	El Segundo	220,000
Texaco Inc.	Wilmington	77,000
Union Oil Co.	Wilmington	104,000
Utility Refining Co.	Ventura	8,000

The major shipping centers are the Los Angeles, Long Beach, and San Diego Harbors which collectively accounted for more the 6,500 ship arrivals in 1973.

Shoreline Use and Ownership

The State of California owns the submerged land off the coast and around each of the Channel Islands for a distance of three nautical

miles. The area of ownership follows the sinuosity of the coastline and each island. The shoreline properties are under private as well as public ownership.

The National Shoreline Study (U. S. Army Corps Engineers, 1971) divides the study area into county segments for describing shoreline use and ownership. The following maps show ownership and use for each shoreline, harbor, and for the Channel Islands. The maps indicate the total coastal miles for each county and establishes reference stations at ten mile intervals.

Santa Barbara County

The Santa Barbara County coastline is 110 miles in length of which half lies within the area of influence. Rocky headlands mark a change from the dominant north-south trend of the California coast to an east-west trend beginning at Point Conception, or the beginning of the study area. The southern portion of the county shoreline runs east-west and consists of narrow sandy beaches predominantly backed by cliffs. The coast is privately owned with the exception of approximately five miles which is reserved for public recreation. Beach access for public recreation is available at Gaviota State Park (Mile 63), Ruffalo State Park (Mile 72), and El Capitan State Beach (Mile 75). The shoreline is relatively undeveloped. The existing non-recreational developments consist mainly of piers, oil derricks, and oil tank farms.

The frontage between Mile 84.0 to 95.9 is characterized as a

sandy beach backed by cliffs. This area extends to Santa Barbar Harbor with the beach becoming very narrow in some portions of the shoreline. Goleta slough empties into the ocean over a small sandbar one mile east of Goleta Point.

Approximately half of the shoreline in this segment is privately owned, with the remainder owned mainly by the State of California, which includes the site of the University of California at Santa Barbara on Goleta Point.

The remainder of the shore line from Mile 95.9 to the Ventura County line consists mainly of sandy beach with localized rocky portions. It is backed by residential and commercial developments along more than half the length.

The shoreline is primarily privately owned. The main exceptions are Santa Barbara Harbor, Carpinteria State Beach and Carpinteria Beach Park. Carpinteria Marsh is privately owned.

San Miguel is the western most of the Channel Islands. Its western point is approximately twenty five miles south of the Point of Conception Lighthouse and its eastern point is about 2.7 miles west of Santa Rosa Island. The island has twenty four miles of sandy beaches, scenic cliffs, and sea caves. There are several places where anchorages and landings are possible, Cuyler Harbor being the largest. The island is owned by the U. S. Navy and landings are not permitted even though no military facilities are maintained on the island. The shore, six miles in length, is bold, broken, and rocky with some stretches and pockets of sand beaches.

Santa Rosa Island is situated about twenty-seven miles southwest

of the Santa Barbara Harbor. The island is privately owned by the Vail Estate and is operated as a cattle ranch with a small portion under cultivation. A small military installation is on the south side of the island.

The shoreline is approximately forty-four miles long and is characterized by bold, high, rocky cliffs. There are approximately twelve miles of sandy shoreline with beaches backed by sand dunes at the western end of the island.

The west end of Santa Cruz Island is about twenty-two miles south-south-west of Santa Barbara and the east end about twenty-four miles south-southeast of the same point. It is the largest of the Channel Islands and has approximately sixty miles of shoreline. The shores are high, steep, and rugged with numerous points and indentations, and is famous for its sea caves. The island has numerous anchorages and landings, and sandy shoreline is found in pocket beaches along the eastern end of the island and in harbors along the northeastern side. The entire island is owned by two families.

Ventura County

Ventura County has approximately forty-one miles of coastline which is predominantly sandy beach with some rocky coastline at the southern end. The backshore is developed over much of the length, especially in the vicinities of Ventura (Mile 14) and Port Hueneme (Mile 24). Bluffs are found in the backshore along the northern portion of the county and cliffs exist along the southern portion. In addition, there are significant lengths of lowlands in the backshore.

The majority of the central coastline is publicly owned and

available for recreation with the exception of the Point Mugu Naval reservation (Mile 31). Harbors along the coastline include Ventura Marina (Mile 16), Channel Islands Harbor (Mile 22) and Port Hueneme Harbor (Mile 24).

The first fifteen miles of the coastline begins at Rincon Point and extends to the City of Ventura. It consists of very narrow cobble beaches. The beaches in some locations are so narrow there is no exposed beach at high tide while the backshore consists of low bluffs of twenty to thirty feet in elevation. The northern shoreline is marked with petroleum installations, while the City of Ventura is located at the southern point.

This portion of the coastline is privately owned except for areas serving as state and county parks. The list of parks include Hoffman, Hobson, and Faria County Parks, Emma Wood Beach State Park, and San Buena Ventura State Beach. The state, under the jurisdiction of the Division of Highways also owns portions of shoreline between the highway and the mean tide line.

From Mile 15.8 to Mile 33.8 lies a sandy beach which extends from the Northern jetty of Ventura Marina to Point Mugu. Much of the backshore consists of lowlands and includes the coastal plain and lagoons of the Santa Clara River and Mugu Lagoon. The remainder of the backshore consists of sand dunes and developments.

More than seven miles of this portion of the coastline are owned by the Federal Government, consisting of Point Mugu Naval reservation and the naval facility at Port Hueneme. The remainder of the shoreline consist of McGrath State Beach and county, city, and private ownership.

The shoreline owned by local government is used primarily for recreation. Ventura Marina, Channel Island Harbor, and Port Hueneme Harbor are found along this segment of the coast. Even though Port Hueneme Harbor is part of the naval reservation, it is also used by commercial interests.

The next segment of the coastline, Mile 33.8 to Mile 41.2 extends from Point Mugu to the Ventura-Los Angeles county line, and consists mainly of a sandy beach backed by cliffs. The beach is generally narrow, 100 to 300 feet in width, and interrupted by small rocky protrusions. The highway is immediately behind the beach because of the closeness of the Santa Monica Mountains. Three miles of the coastline is within the Point Mugu State Recreation Area, while the remainder is privately owned and undeveloped.

Anacapa, in Ventura County, and Santa Barbara Islands, in Santa Barbara County, have approximately twenty miles of coastline, and are similar in physical characteristics. Both islands are administered by the National Park Service and include the Channel Islands National Monument. They are both characterized by sea cliffs up to five hundred feet in height with a few small rocky bays and insignificant sandy pocket beaches.

Los Angeles County

The shoreline of Los Angeles County is seventy four miles long and extends from Sequit Point on the north to the San Gabriel River on the South. The coastline includes two prominent headlands, Point Dume (Mile 9) and Palos Verdes Peninsula (Mile 50). Two bays are also included in the stretch, namely, Santa Monica Bay (Mile 28) and San Pedro Bay (Mile 64). The latter is the site of the Los Angeles, Long

Beach Harbor. The shoreline is characterized by a sandy beach backed by cliffs in the northern portion and by extensive urban developments behind the beaches along the southern portion of Santa Monica Bay. The coastline of Palos Verdes Peninsula is rocky with pocket beaches of either sand or cobbles. The southern stretch is the highly developed Los Angeles, Long Beach Harbor area.

The northern cliffed area of the Los Angeles County shoreline and the Palos Verdes Peninsula region are predominantly privately owned, while the southern Santa Monica Bay area extending from the Santa Monica Mountains to the Palos Verdes Peninsula is publicly owned and used for recreation. Much of the Los Angeles, Long Beach Harbor area is owned by the Federal government and other local governmental agencies.

The first ten miles of the coastline near Sequit Point to Point Dume is a sandy beach backed by cliffs. There is some development on the cliff area, mainly of the residential type. A majority of the coastline is privately owned, however, public recreation is available at Leo Carrillo State Beach, Zuma Beach County Park, and part of Point Dume State Beach.

A sandy beach extends from Mile 9.0 to Mile 29.6, or from Point Dume to the Santa Monica pier. The beach is narrow in the northern portions and wider in the southern most portion of the stretch. The backshore is almost entirely developed, mostly residentially. The developments and the coast highway are immediately behind the sandy beach because of the proximity of the Santa Monica mountains.

Approximately three-fourths of this portion of the coastline is privately owned. Public recreation is available at Malibu Lagoon, Las

Tunas and Will Rogers State Beaches, and at portions of Santa Monica and Point Dume State Beaches. The Santa Monica anchorage is located at the southern end of the stretch.

The next segment of coastline extends from the southern shoreline of Santa Monica Bay to the northern part of Palos Verdes Peninsula (Mile 29.6 to 45.6). The shoreline consists of wide sandy beaches with developed backshore immediately behind the beach. The development consists primarily of residential uses, but major structures such as an oil refinery and power plant are located in the immediate backshore.

Almost sixteen miles of this portion is publicly owned and available for recreation. Public recreation is available at Santa Monica, Dockweiler, Manhattan and Redondo State Beaches, and Torrance County Beach. Small craft harbors are found at Marina del Rey and King Harbor.

The segment of coastline extending from Palos Verde Peninsula at Malaga Cove to Los Angeles Harbor, Mile 54.6 to Mile 62.4, is comprised primarily of rocky cliffs and headlands with small pocket beaches of sand or cobbles. The cliff tops consist primarily of residential development. Cabrillo Beach, a public development is located at the southern portions of the stretch.

Just over one mile of the shoreline is owned by the Federal Government and used for the Point Vicente and Point Fermin Lighthouses and for the Fort MacArthur military reservation. Approximately two thirds of the remainder is privately owned with the remaining third used for public recreation. The recreational sites include Point

Vicente County Park, Royal Palms State Beach and Cabrillo Beach Park. Although a majority of Palos Verdes Peninsula is privately owned, the rocky beaches and sites at the base of the cliffs are accessible to the public.

The southern section of the coastline in Los Angeles County extends from the Los Angeles River to the Los Angeles, Orange county line. The section consists of a sandy shoreline backed by urban developments. The entire stretch is publicly owned and is used for public recreation, with the exception of a U. S. Navy landing area near the mouth of the Los Angeles River. Recreation facilities include the Rainbow Lagoon area of the city of Long Beach and Bluff Park which is connected to the mainland by four overhead bridges. The harbor area is bounded on the north by the steep vertical cliffs of Point Fermin fronting San Pedro, and on the south by the ocean entrance of the Los Angeles River. The area between the boundaries is primarily reclaimed swamp and marsh land providing space for commercial port activity, small boat recreation facilities, and a U. S. Navy Base.

Santa Catalina Island lies approximately eighteen miles south of Los Angeles Harbor and the principal urban areas are Avalon and Isthmus Cove. The shoreline is predominantly rocky but there are numerous pocket beaches. The island is privately owned but public recreation is available at Avalon, Isthmus Cove and Catalina Harbor. Many of the small pocket beaches on the sea side are maintained by organizations for private recreation.

San Nicolas Island, in Ventura County, is the most seaward offshore island and is located sixty miles south west of Los Angeles

Harbor. It is a naval reservation and the water surrounding it is controlled by the Eleventh Naval District. The western part of the island is covered with sand, and with the exception of the rocky points, the beaches are all sand.

Orange County

The Orange County coastline extends from the San Gabriel River south to the city of San Clemente, and is forty two miles in length. It is almost entirely sandy beaches interrupted by occasional rocky headlands in the region from Corona del Mar (Mile 18) to Dana Point (Mile 32). The northern portion of the county coastline down to Newport Beach is almost totally developed as is the southern most segment between Dana Point and San Clemente. The central region between Newport Beach and Dana Point is backed by cliffs and bluffs.

Ownership along the Orange County shoreline is represented by alternating stretches of publicly and privately owned beaches. The sole exception is the U. S. Naval Weapons Station at Anaheim Bay. The majority of the shoreline is suitable for recreation. Major public recreation is located at Huntington Beach, Newport Beach, Laguna Beach, Dana Point, and San Clemente. Harbors on the coastline include Anaheim, Sunset, Newport Bay, and Dana Point Harbor.

The eighteen mile section of the shoreline extending from the San Gabriel River to Corona del Mar is comprised entirely of sandy beaches interrupted only by harbor entrances and river jetties. Most of the shoreline is owned by local government and is available for public recreation. Exceptions are the Federally owned entrance to Anaheim Bay and a 2.3 mile section of private ownership immediately up the coast

from the Huntington Beach pier. Public beaches include Seal, Surfside, Sunset, Bolsa Chica, Huntington, Newport, and Corona del Mar. The U. S. Naval Weapons Station encompasses the entrance to Anaheim Bay which extends to the developed area of Sunset Bay and to Bolsa Bay which is undeveloped except for scattered oil wells. The two jettied entrances in this coastline segment are Anaheim Bay a deep draft military harbor, and Newport Bay, a small craft harbor.

From Corona del Mar (Mile 18.1) to Dana Point (Mile 32.7) the coastline is rocky with numerous small pocket beaches frequently interrupted by rock outcroppings. The greater portion of the shoreline is backed by escarpments rising to heights of 30 to 130 feet. The backshore is highly developed at Corona del Mar, Laguna Beach, and South Laguna. The remainder of the backshore area at the crest of the cliffs is relatively undeveloped for a seven mile segment.

Over two thirds of this section of the coast is privately owned with the remainder under the jurisdiction of city and county governments. Public recreation is centered primarily in the Laguna Beach area.

The southern stretch of the Orange county coastline (Mile 32.7 to Mile 42.0) called the Capistrano Bight, extends from Dana Point Harbor to San Mateo Point. It consists of sandy beaches backed by cliffs rising to one hundred feet in height. Approximately one half of the backshore is developed, and the Atchison-Topeka and Santa Fe Railroad line is immediately behind the beach for approximately seven miles of the backshore. San Juan Creek enters the sea approximately one mile south of Dana Point Harbor.

Over two thirds of the coastline is publicly owned and used for recreation including Doheny and San Clemente State Beaches. The remainder, also suitable for recreation, is privately owned.

San Diego County

The shoreline of San Diego County is seventy six miles in length and extends from San Clemente to the International Boundary. The coastline is characterized by sandy beaches along the entire length with the exception of the two areas of La Jolla (Mile 45) and Point Loma (Mile 60), which both have rocky coast lines. Most of the backshore is cliffs interrupted intermittently by estuarine or lagoonal backshore.

Approximately seventeen miles of the northern county coast is included within the U. S. Marine Corps Camp Pendleton Military Reservation. Use of the beach area is restricted to military operations and personnel. The remainder of the coast down to La Jolla is primarily publicly owned and used for public recreation. La Jolla Mesa is privately owned, and most of Point Loma is under Federal ownership. The Silver Strand below San Diego Bay has both private and public ownerships. Harbors include the Oceanside small craft harbor, Mission Bay, and San Diego Bay.

The Mile 0.0 to Mile 17.7 segment of coastline extends from San Mateo Point to the mouth of the San Luis Rey River immediately north of Oceanside. The northern three miles is a beach formed at the confluence of San Mateo and San Onofre Creeks.

A sandy beach averaging approximately one hundred feet in width continues southward to the end of the stretch at the southern end of

the portion, the beach is backed by the San Onofre cliffs ranging from sixty to one hundred fifty feet in height, cut by intermittent streams and occasional landslides. The southern three miles of the coastline is backed by the Santa Margarita Lagoon. Both the San Mateo and the Santa Margarita wetlands are still in a relatively natural state.

The entire seventeen mile segment of the coast is part of the Camp Joseph H. Pendleton Military Reservation. Use of the beach area is restricted since the beaches and backshore are used for military purposes. The entire segment is essentially undeveloped with the exceptions of the San Onofre Nuclear Power Plant, and the Camp Del Mar Installation Harbor. One Oceanside small craft harbor is located just north of the San Luis Rey Creek and shares the same entrance structure with the military Del Mar Boat Basin.

The next coast line segment, Mile 17.7 to 39.0, is a sandy beach located between the San Luis Rey River and the Soledad River. The beach varies from one hundred fifty to four hundred feet in width and is backed by intermittent cliffs. Several flooded river mouths behind bay mouth bars occur in the area. The estuaries and lagoons include Buena Vista Lagoon, Agua Hedionda Lagoon, Batiguitos Lagoon, San Elijo Lagoon, San Dieguito Lagoon, and Soledad Valley Lagoon.

Approximately two thirds of the stretch is owned by local government and is available for recreation. The public recreation beaches include the State Beaches at Carlsbad, South Carlsbad, Ponto, Moonlight, San Elijo, and Cardiff, and County Beaches at Encinitas, Seaside Gardens, Sea Cliff, Tide Beach, and Solana Beach. The remainder is privately owned and used for private recreation.

The next southerly portion of the coastline, Mile 39.0 to Mile 52.7, extends from the northern region of the Torrey Pine Bluffs southward to the entrance of Mission Bay park and includes the La Jolla Bay and La Jolla Mesa Peninsula. This stretch consists mainly of sandy beaches and a small distance of rocky coast. A flat sandy beach ranging from one hundred to two hundred fifty feet in width extends in front of Torrey Pine Bluffs and southward into La Jolla Bay. Southward from the rocky peninsula the shoreline becomes a sandy beach and fronts the communities of Pacific Beach and Mission Beach. Most of the section is owned by local government and is available for public recreation. The length includes the Torrey Pines State Reserve, Scripps Institute of Oceanography, and Pacific and Mission Beaches. The remainder is privately owned but is also used for recreation.

The next section of the coast from Mile 53.7 to Mile 61.7 begins at the entrance to Mission Bay and extends southward to Ballast Point at the entrance to San Diego Bay. The coastline is rocky coast with a small section of sandy beach less than one mile in length and extends to the Point Loma area. The majority of the lands on the peninsula are under Federal ownership and includes the Fort Rosecrans Military Reservation and the U. S. Coast Guard Reservation.

The next major span of coastline runs from the entrance of San Diego Bay and extends southward to the Mexican border (Mile 61.7 to Mile 76.0). The stretch is characterized as a sandy beach interrupted only by the Tijuana River delta. The Federal Government owns most of the shoreline with military bases as the most common use. The list of bases include the San Diego Naval Air Station, The Naval Radio Station

at Imperial Beach and the Ream Field Station at the International Border. In addition, the U. S. Navy has leased 2.6 miles of the Silver Strand State Beach. There are only two miles of strand beaches available for public recreation in addition to the public beaches located in the City of Coronado and Imperial Beach.

Mission Bay starts at Mile 52.8 on the San Diego County coastline. The 5000 acre swamp and marsh land was reclaimed by the City of San Diego in order to provide an additional eighteen miles of recreational shoreline. Many small coves with fingers of land which are leased to private enterprise are located on the westerly portion of Mission Bay. The City of San Diego owns all the shoreline except for 2.5 miles of segment at the north end of the bay. Approximately one fourth of the shoreline is leased for commercial recreation activities consisting of yacht clubs, restaurants, boat yards, motels, and an aquarium. Interior portions of the coves are used for swimming and boating. The easterly portion of the bay and the shoreline, which includes a large undeveloped island, is reserved for a wildlife sanctuary.

San Diego Bay is a naturally formed tidal lagoon configuration and included thirty-one miles of shoreline which is under the jurisdiction of the Unified San Diego Port Authority. The numerous naval activities and facilities have a decided effect on the use of the bay.

San Clemente island is located about sixty miles northwest of San Diego Bay. The island serves as a United States Naval Reservation and is closed to public use since it is use as a range for gunfire and bombing.

Table II-53 summarizes the various categories of the

coastline for each county. The major items covered include physical characteristics, ownership, and use. Figures II-81 through II-88 show ownership and use of the coastline.

Table II-53
Coastline Classification
by County 1971
(Includes Channel Islands)

<u>Physical Characteristics</u>	<u>Santa Barbara</u>	<u>Ventura</u>	<u>Los Angeles</u>	<u>Orange</u>	<u>San Diego</u>	<u>Total</u>
Beach	101.2	41.4	86.8	34.2	71.7	335.3
Non Beach	118.6	0	88.1	7.8	103.3	317.8
<u>Coast Ownership</u>						
Federal	36.7	27.2	28.6	0.8	93.8	187.1
Other Public	15.0	21.3	56.3	25.0	45.3	162.9
Private	168.1	12.7	90.0	16.2	35.9	322.9
<u>Coast Use</u>						
Recreation, Public	13.3	38.2	36.5	25.5	52.6	166.1
Recreation, Private	9.5	2.7	22.5	13.6	12.2	60.5
Non Recreation Development	6.4	8.8	31.0	1.8	21.8	69.8
Undeveloped	190.6	11.5	84.9	1.1	88.4	376.5

Source: U.S. Corp of Engineers 1971.

OWNERSHIP



FEDERAL



NON-FEDERAL PUBLIC



PRIVATE



UNCERTAIN

USE



PUBLIC RECREATIONAL



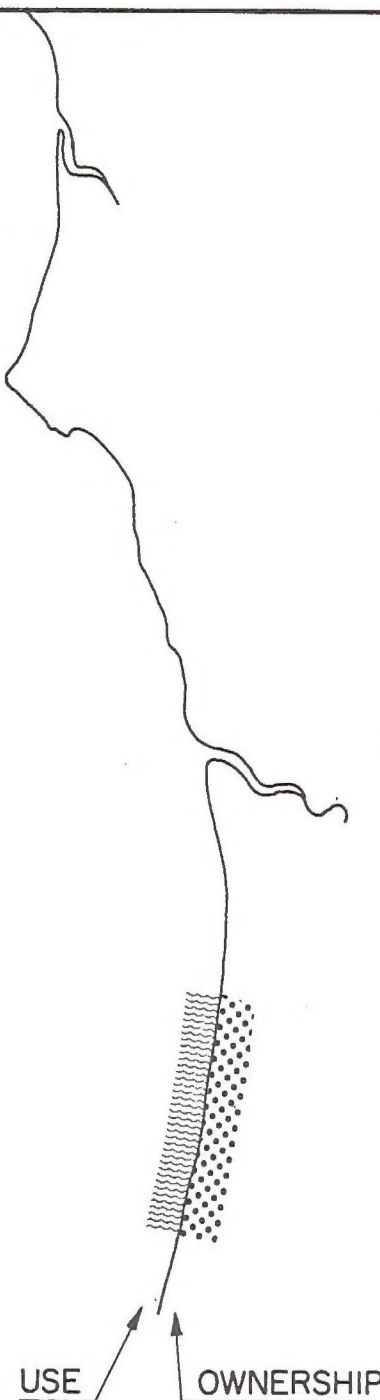
PRIVATE RECREATIONAL



NON-RECREATIONAL DEVELOPMENT



UNDEVELOPED



USE

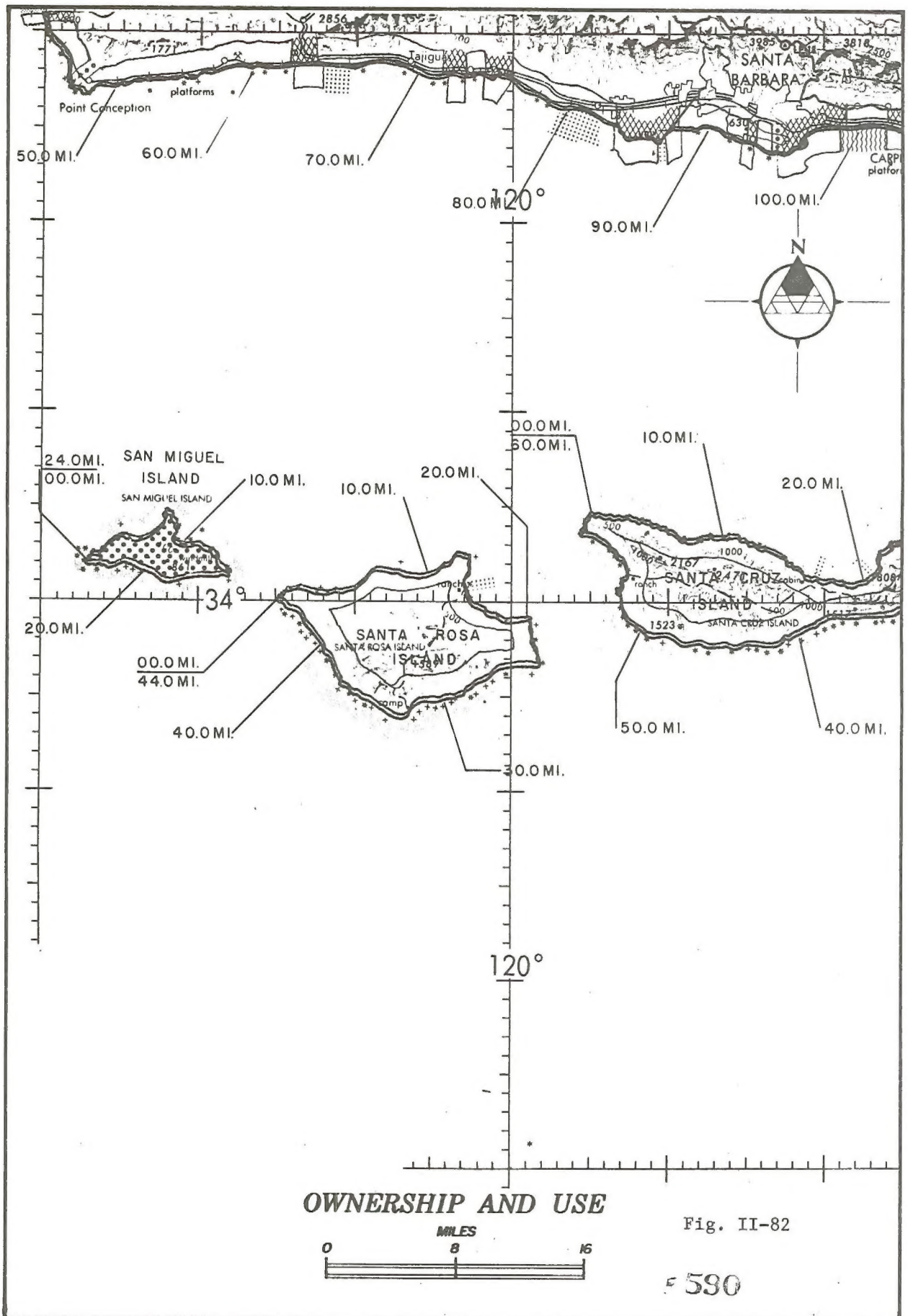
OWNERSHIP

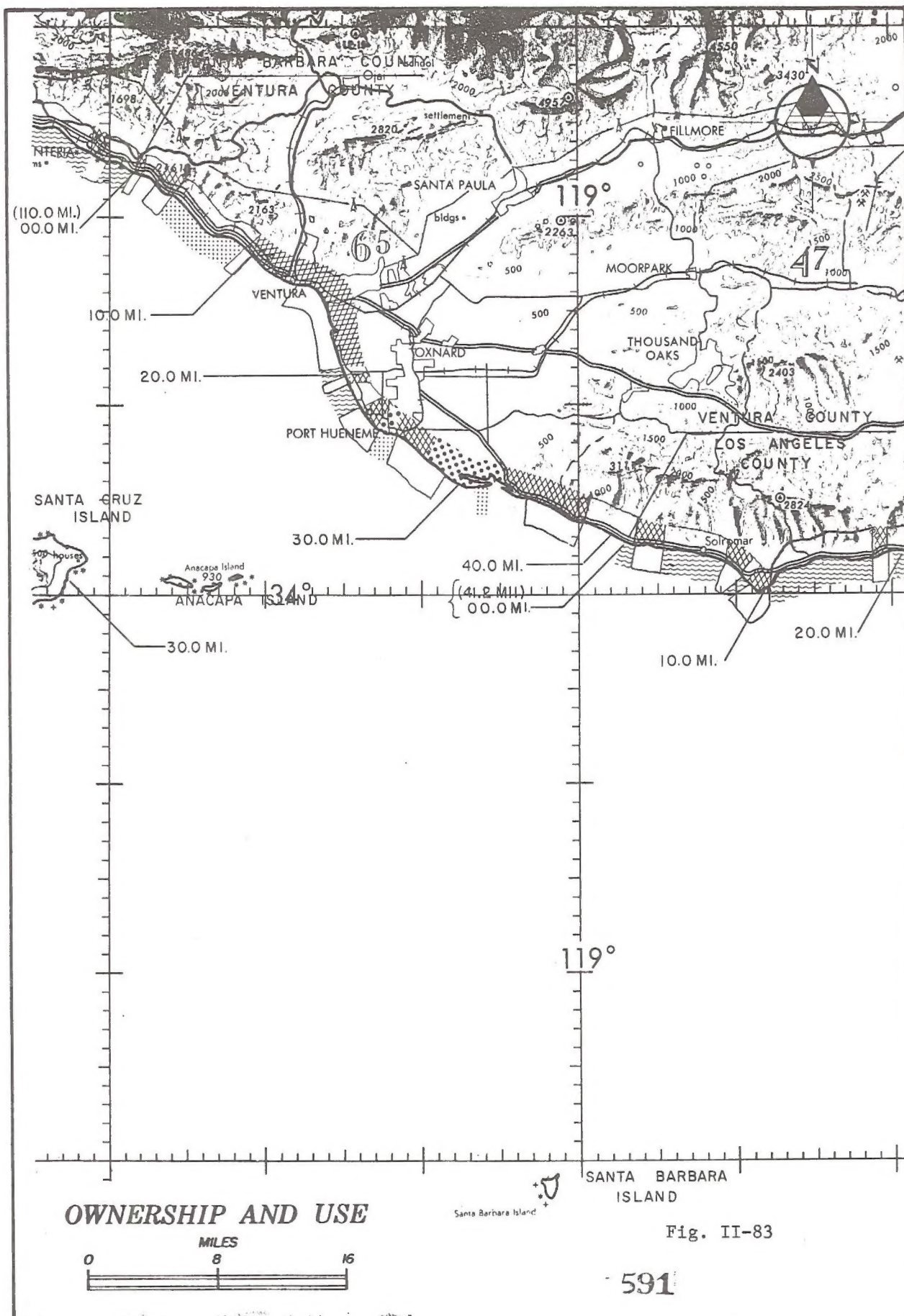
LEGEND

OWNERSHIP AND USE

Fig. II-81

589





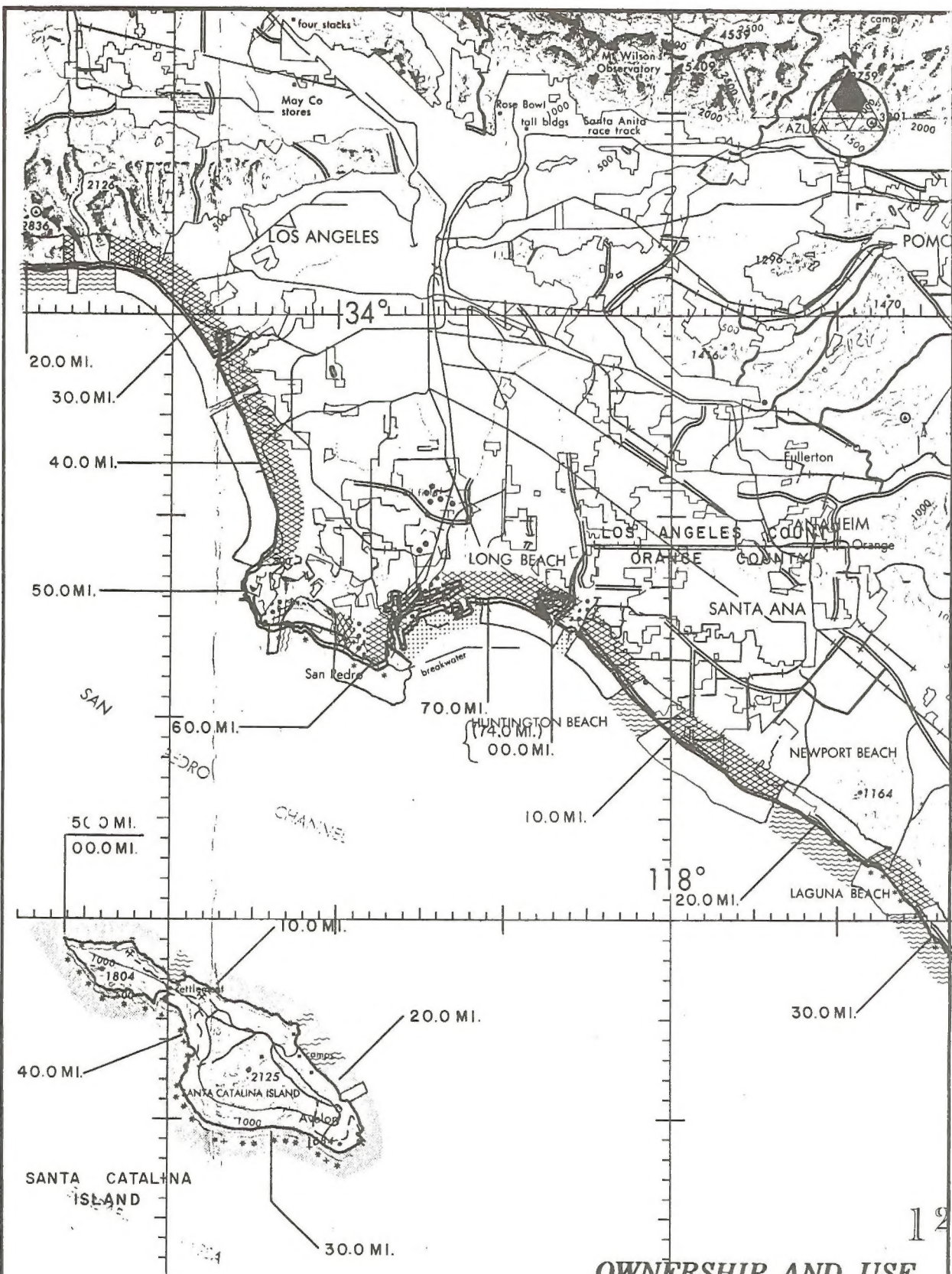


Fig. II-84

OWNERSHIP AND USE



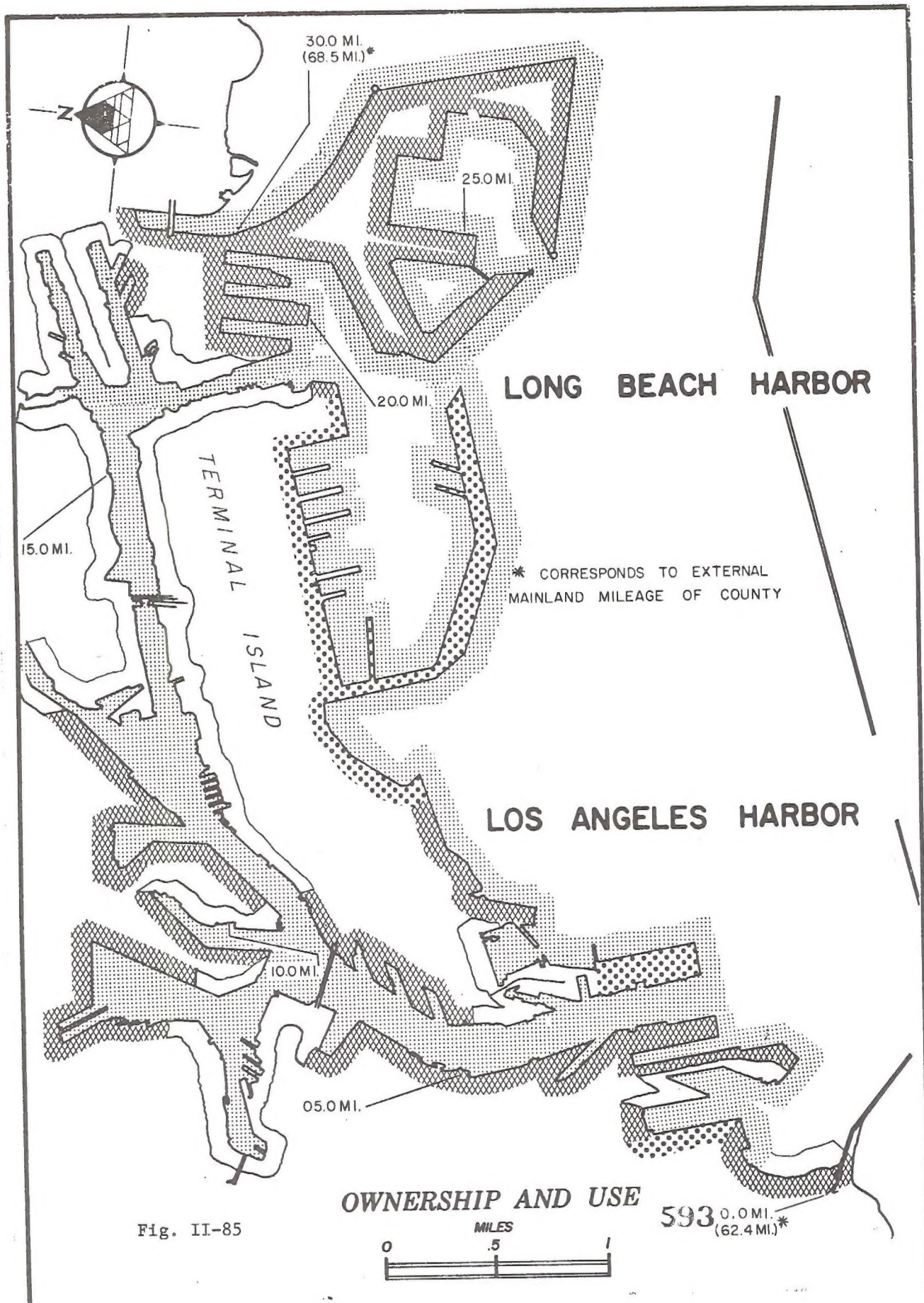


Fig. II-85

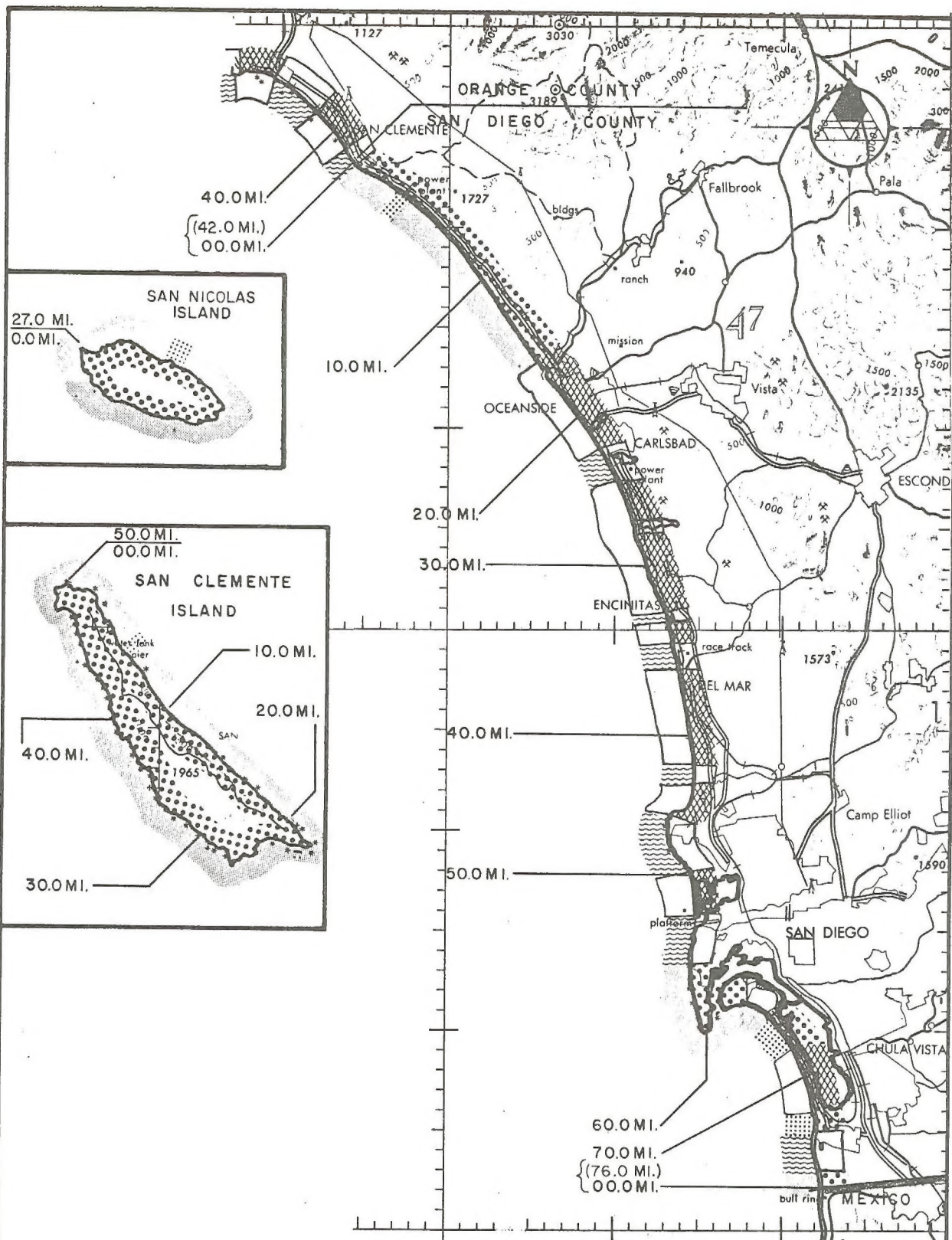
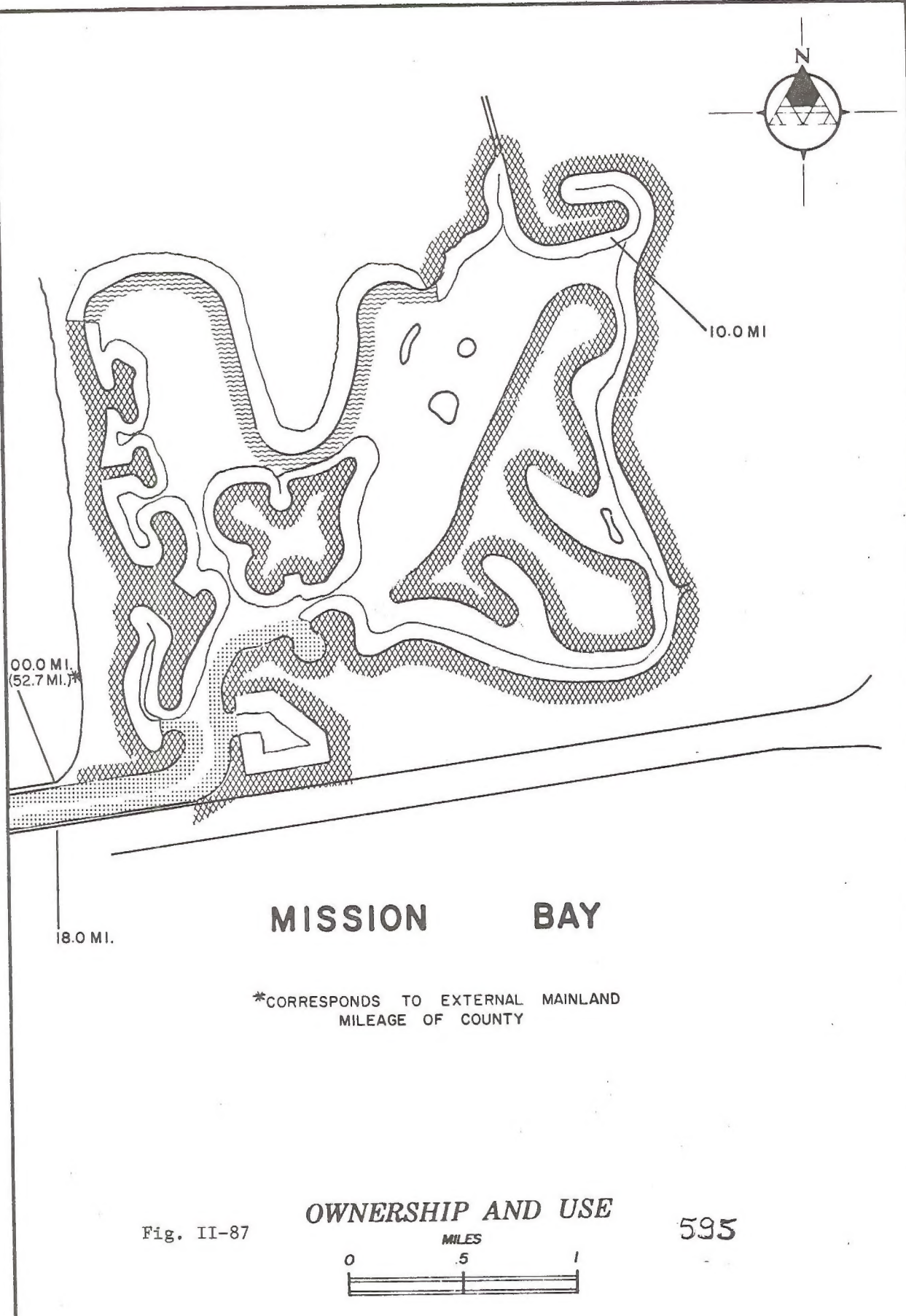


Fig. II-86

OWNERSHIP AND USE



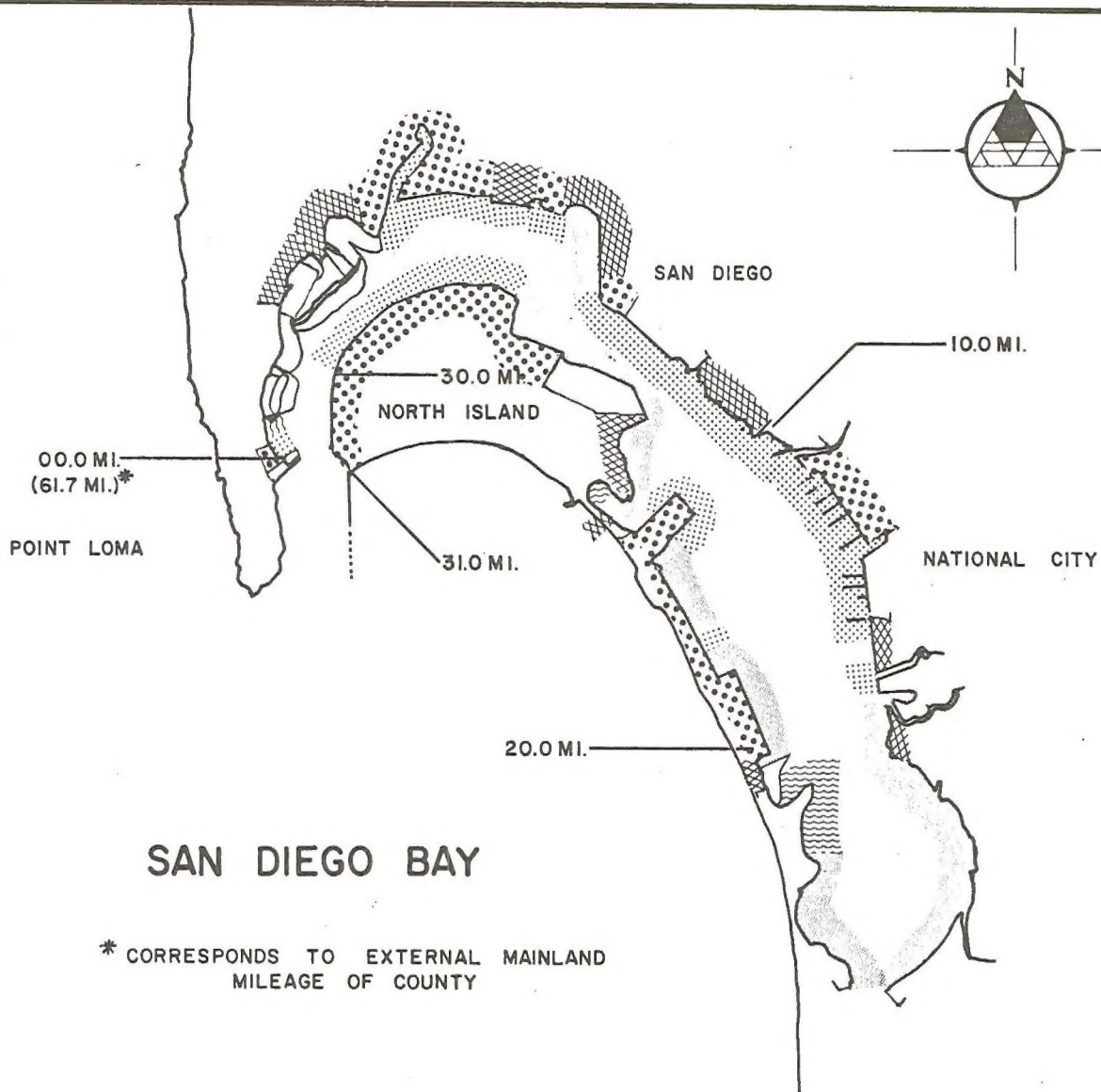
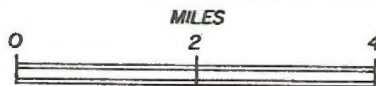


Fig. II-88

OWNERSHIP AND USE



2. Ocean Dumping Areas and Military Use

a. Ocean Dumping Areas

There are sixteen documented ocean dumping sites within the Southern California Bight (Smith and Brown, 1971; Brown, 1970; COMTHIRDFLT, 1973). These sites were used for disposal of industrial dumping (moratorium U. S. Dept. of Navy 1971), military, and commercial wastes until 1972 and the enactment of the Marine Protection, Research, and Sanctuaries Act.

The disposed material was composed of: industrial chemicals, aerospace industry waste, petroleum refinery wastes, obsolete or unserviceable military munitions, toxic chemical ammunition, nuclear industry and laboratory radioactive waste materials.

Graphic 2 shows 16 ocean dumping areas documented by Brown (1970) and United States Navy emergency aircraft ordnance jettison areas. These disposal areas, numbers 15 and 16, are located at: primary jettison area (#16) 33° N. Lat. - 117° 48' W. Long, and secondary jettison area (#15) 33° N. Lat. - 118° 15' W. Long. These two areas are located approximately between the northern tip of San Clemente Island and the California coast at Solano Beach in 900 meters of water.

Depths of the other disposal sites are stated in Tables G 2-1 and G 2-2 in Appendix 10, G.2 and are located in water over 400 meters deep (exceptions are #8, 119 meters and #13, 366 meters).

Ocean dumping under the 1972 Act is regulated by permits issued by the United States Environmental Protection Agency. At the present time there has only been one such permit issued, application #0073-02, this to H-10 Water Taxi Company Ltd., San Pedro, California for foreign

vessel refuses disposal. This permit expires in January of 1975 and is not expected to be renewed since the Port of Los Angeles and/or Long Beach anticipate other disposal methods for foreign vessel generated waste material.

b. Military

The continental shelf of Southern California is used by the United States armed forces for a variety of purposes. Those operations which may impose upon normal marine use by the public are cited in: U. S. Coast Pilot #7 Pacific Coast (1968); Commander Third Fleet Operations Manual 3120 H (1973); Commandant Eleventh Naval District Local Notices to Mariners Annual Publication (L-YR); and depicted on National Ocean Survey Maps, #5101 and #5202 (U. S. Dept. of Commerce 1973); and Naval Oceanographic Office Map, #18004 (1973). Also see Graphic 2 of this statement.

The major portion of the area (Southern California Bight) falls within the Pacific Missile Range which covers 14,000 square miles and extends 160 nautical miles west and 90 nautical miles south of Point Mugu. This area is used for jet powered target flights, tactical missile launches and flights, manned and unmanned aircraft flights, bomb drops, anti-submarine warfare weapons, and general gun firings. Access is controlled during hazardous operations by radio broadcasts, patrol craft, and notices in "Local Notice to Mariners" published weekly by the 11th Coast Guard District, Long Beach.

South of Point Mugu and the Pacific Missile Range, extending to San Diego and at varying distances from the coast are several Naval operations areas (described in COMTHIRDFLT INST, 1973): Long Beach

Electronic Test Area, San Pedro; Channel Operations Area; Santa Barbara Island Training Area; San Clemente Firing Area; Shore Bombardment Area (San Clemente Island); Anti-submarine Rocket Training Area; Camp Pendleton Amphibious Training Area; Cortes Bank Carrier Operations Area. These Areas are used for all weather fleet training, refueling, test flights, rockets, bombs, anti-submarine warfare, all weather flight training drones, carrier and submarine operations, anti-aircraft and surface gunnery and miscellaneous military operations.

Included in the above areas and extending through the Pacific Missile Range are submarine transit lanes into the Port of San Diego (NOS. maps, #5101 & 5202). See also Graphic 1 of this statement.

In addition to the above operations areas there are two smaller areas of interest: The small arms practice firing range for the United States Army Reserve, National Guard, and Coast Guard units off of Point Fermin (patrolled during firing sessions by safety observers), and the Santa Cruz Anti-submarine Warfare Test Facility, located south of the eastern end of Santa Cruz Island.

3. Recreation and Allied Resources

a. Recreation

Recreation is an important component of Southern California's environment and economy. An abundance of opportunity combined with a large, highly mobile population, creates a situation unparalleled elsewhere in the country. This section discusses the existing population, usage and resources of Southern California.

Population

Population has a large effect on recreation demand and ability to meet such demands with density and distribution patterns as important factors. Southern California has undergone an explosive rate of population growth over the greatest part of the past two decades but evidence that the rate has declined in the seventies is strong. Los Angeles County, for example, has had a net outmigration evidenced as long ago as 1968 and continuing to the present, with actual population losses in the past 2 or 3 years. Orange County, in contrast has shown continued strong increases through the present time.

Southern California gained 3.4 million people in the decade 1950-60 declining to a gain of 2.7 million between 1960-70. Growth rates will likely remain much reduced until the onset of another boom industry such as the defense and aerospace expansions of the late 50's and early 60's.

Lowered growth rates have been attributed to growing congestion, pollution, earthquakes and urban sprawl. Cutbacks in NASA, Dept. of Defense and other high technology industrial contracts combined with

economic recession has made the Southern California economic climate less attractive than it had been in the past. The regional economy remains strong but does not enjoy the rampant expansion of the earlier period.

Environmental considerations may restrict a recurrence of the past's rapid expansion through such means as stricter zoning, restricted availability of public services and limitations on atmospheric pollutants.

Rural populations exert a much lower demand for recreation resources than do urban areas. Rural people have open space and outdoor recreation opportunities near at hand. They are also not subjected to the pressures of urban existence and are not as compelled to seek relief and self-renewal in the natural environment. Population in the five Southern California Counties ranges from 88.5% urban in Santa Barbara County to 98.8% urban in Orange County. Southern California averages 97.6% urban while the state population as a whole, is 90.9% urban.

Population characteristics of Southern California match very closely those of the nation. Children under 5 and 5-17 years of age compose 8.4% and 16.0% of the population respectively for Southern California and 8.4% and 16.1% for the nation. Age group 18-65 years and over 65 years are 66.8% and 8.5% of Southern California, respectively and 65.6% and 9.9% for the nation.

Growth will continue but not at the explosive rate of the past for the region. Population expansion will occur mainly in Orange County followed by San Diego and Ventura counties.

	<u>County Population</u> <u>1970¹</u>	<u>Forecast 1974²</u>
Santa Barbara	264,324	280,000
Ventura	376,430	440,000
Los Angeles	7,036,463	6,948,000
Orange	1,420,386	1,699,000
San Diego	1,357,782	1,538,000

¹Source-U.S. Dept. of Commerce, Bur. of Census, *County and City Data Book, 1972.*

²Source-United Calif. Bank, Res. and Planning Div., *1974 Forecast, 1973.*

Decreased rates occurred due to a decline in net migration, lowered birth rate and rise in the number of resident deaths. According to U.S. Census Bureau estimates, the birth rate for women in the 18-24 year old bracket declined from 2.9 per woman in 1955, to 2.6 in 1967, and reaching 2.1 by 1972. High birth rates are not likely to be reached again which indicates a lower rate of population growth.

Geographically, most of California's population occurs within the coastal strip and predominantly along the southern portion of it. This results in great pressure upon large portions of the coast for both recreation and other land uses. This pattern of population distribution will continue for the foreseeable future.

Tourism

Tourism is the third largest industry in Southern California and supports approximately a million jobs according to the Southern California Visitors Council. In 1973 an estimated 8.5 million out-of-state U.S. visitors (not including those attending conventions or traveling on business) spent almost \$2 billion in

Southern California. In addition to out-of-state tourists an estimated 2.1 million people visited Southern California from other parts of the state plus a growing number of foreign travelers. The overall economic benefit gained from tourist expenditures in Southern California is important in that it adds to the economic well-being of the area by contributing directly and indirectly to almost every sector of regional economic activity. The direct impact of visitor spending is discernible through expenditures and from the number of employees and their dependents directly supported by tourism in service related activities.

Also of economic significance is that dollars spent by tourists represents "new money"--money earned elsewhere and spent here in a service industry typified by rapid dollar turn-over and a high multiplier effect within the local economy. It has been estimated that the overall effect of tourist expenditures on the regional economy is close to 2 times the dollar amount of these expenditures as a result of the multiplier effect or dollar turn over. Thus the total impact of tourist spending would not be the direct expenditure of almost \$2 billion but closer to \$4 billion.

Another important benefit derived from tourism is in the form of taxes paid by the visitor. In 1973 tourists paid an estimated \$119 million in taxes while making relatively small demands on such services as police, fire protection, etc. These taxes represent a significant contribution to the Southern California economy. The principal taxes paid by tourists are the retail sales tax and the

gasoline tax. A portion of the retail sales tax is rebated to the local communities. The gasoline tax collected in Southern California also benefits the region through a better system of freeways and through rebates to the counties and cities for local road improvement.

In 1973 the major recipients of the \$1,966 million tourist expenditures in Southern California were establishments engaged in the sale of food and beverages (23.2 percent) and hotels and motels (22.3 percent). In addition, visitors allocated 17.0 percent of their expenditures to theatres, sports, and other recreational activities; and purchases of gasoline and other automobile products or services accounted for 14.0 percent. Clothing establishments were another prime beneficiary of 1973 tourist expenditures in Southern California, receiving 11.2 percent.

In spite of an economic slowdown and growing inflation since mid-1973, and energy shortages during the last quarter of 1973 and first quarter of 1974, a record 8,446,000 out-of-state visitors came to Southern California in 1973. Hence, the impact of energy shortages on tourist arrivals in Southern California was slight, and the crisis (which lasted from late December 1973 through March 1974) appears to have resulted primarily in a shift in the mode of transportation employed. During this period, an increased percentage of the visitors to Southern California arrived by airline or train. On the other hand, there was a corresponding decline in the proportion of visitors arriving by automobile.

It must be remembered that travel and most recreation are based

on the mobility of people coming into the state and/or moving around in it by means of fuel-dependent vehicles--automobiles, aircraft, trains and buses. In its simplest terms tourism, like "travel," is the movement of people through various modes of transportation upon which they are dependent. In the event of another fuel shortage the major impact would probably be a continued shift to the common carrier and away from the private automobile. There would of course be some loss in trade which would be expected to increase indirectly in relation to the increased severity of the fuel shortage.

In connection with this the Southern California Visitors Council conducted a survey by sending questionnaires to people who had written for information. Of those who requested information but did not visit Southern California 11 percent listed the reason as the energy shortage. This was fourth on a list headed by illness in the family, not enough money, or not enough time to make the trip.

The 1960's, a decade of economic expansion, saw steady increases in the number of visitors to Southern California. An economic slowdown caused tourist arrivals to level off in 1970 and decline somewhat in 1971. Since 1971, the number of visitors to Southern California has continued to expand but at a very modest rate.

Historically, the trend in tourist expenditures has paralleled that of tourist arrivals. However, a significant increase in the rate of inflation in 1973 (led by sharp increases in the cost of food and fuels) resulted in tourist expenditures during that year expanding at a significantly faster rate than the number of visitors. This is reflected in the following table, II-53.

TABLE II-53

SOUTHERN CALIFORNIA TOURIST ARRIVALS AND EXPENDITURES, 1968-1974

	<u>1968</u>	<u>1969</u>	<u>1970</u>	<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>First Five Months</u>	
							<u>1973</u>	<u>1974</u>
Number of Tourists Arriving in Southern California (in thousands)....	7,882	8,185	8,248	7,599	8,125	8,446	3,042	3,118
Percent change compared to 1968 (Base year).....	--	3.8	4.6	- 3.6	3.1	7.2	--	--
Tourist Expenditures in Southern California (in millions of \$).....	\$1,242	\$1,271	\$1,461	\$1,320	\$1,402	\$1,966	808	n.a.
Percent change compared to 1968 (Base Year).....	--	2.3	17.6	6.3	12.9	58.3	--	--

Source: Southern California Visitors Council

The seasonal characteristics of tourism in Southern California have changed considerably since the early 1900's. During earlier periods, the tourist season was almost exclusively the winter months, as the wealthy and more affluent people vacationed in Southern California to escape the harsh eastern winters.

At present, tourism is a year-round business, with the greatest number of visitors arriving during the summer months when families can take advantage of school vacations. In spite of this shift, Southern California has not lost its appeal to winter vacationers. It is interesting to note that per capita tourist expenditures are highest during the winter months (see Table II-54).

In the survey conducted by the Southern California Visitors Council it was indicated that 60 percent of the out-of-state visitors to Southern California in 1973 lived east of the Mississippi River. The greatest concentration of visitors came from the east-north-central and mid-Atlantic areas of the United States, each of which accounted for 22 percent of the visitors to Southern California. The east-north-central area includes the states of Illinois, Indiana, Michigan, Ohio and Wisconsin. New York, New Jersey and Pennsylvania comprise the mid-Atlantic states. Significant proportions of visitors to Southern California also came from the mountain states (11 percent), the west-north-central region (9.5 percent) and the south Atlantic states (9.6 percent). The attractions which Southern California has to offer the tourist are many and varied. Those who like outdoor recreation have the mountains, desert and excellent beaches to choose from while others may be attracted to the cultural activities found

TABLE II-54

SOUTHERN CALIFORNIA TOURIST ARRIVALS
AND EXPENDITURES BY MONTH, 1973

	<u>Tourist Arrivals</u>	<u>Tourist Expenditures</u>	<u>Expenditures Per Tourist</u>
January.....	562,000	\$ 173,000,000	\$308
February.....	533,000	168,000,000	315
March.....	606,000	193,000,000	318
April.....	686,000	134,000,000	195
May.....	655,000	140,000,000	213
June.....	848,000	183,000,000	216
July.....	943,000	153,000,000	162
August.....	959,000	160,000,000	167
September.....	814,000	140,000,000	172
October.....	655,000	177,000,000	270
November.....	602,000	168,000,000	279
December.....	<u>583,000</u>	<u>177,000,000</u>	<u>304</u>
Total	8,446,000	\$1,966,000,000	\$233 <u>1/</u>

1/ Weighted average

Source: Southern California Visitors Council

in the larger cities. Just as important, however, are the number of commercial attractions, most famous of which is Disneyland. Others include Knotts Berry Farm, Marineland, Lion Country and Japanese Village (now closed) all located in the Los Angeles-Orange County areas, and Sea World located in San Diego. Southern California also has outstanding zoos located in Los Angeles and San Diego. The area also offers a temperate climate which can be enjoyed the year round.

The current outlook for tourist activity in Southern California is that only a modest increase in activity is expected. The number of visitors during the first 5 months of 1974 is only slightly greater than for the same period a year earlier. Recent economic uncertainty and increases in the rate of inflation appear to have some effect.

As these problems diminish and with rapid gains in personal income levels the long term outlook is for a healthy growth of this industry in Southern California.

Physical Resources and Usage

Regional recreation facilities include a diverse array of opportunities ranging from ocean oriented activities such as surfing and fishing, to mountain activities like hiking and skiing. This variety lends much to the attractiveness of the region.

Recreation options exist although most opportunities are fully exploited, thus there is no surplus of any particular facility. Dislocation in one recreation type cannot be readily absorbed elsewhere as a result. Regional recreation supplies will then materially

affect coastal recreation pressures.

Table II-55, adapted from the California Department of Parks and Recreation, Parks and Recreation Information System (Paris), summarizes physical facilities of record that are available. For purposes of this analysis, those recreation sites within the immediate coastal area and seaward are to be directly considered.

Santa Barbara County

Santa Barbara County has 110 miles of coastline of which this document will consider the 61 miles extending easterly from Pt. Conception.

Of this 61 miles, 15 miles are publicly owned and 46 are private. Public recreational use occurs on 13 miles with private recreational use on 10 miles. Non-recreational development occurs on 6 miles and 32 miles remain undeveloped. Fifty-six miles, or 92% is classified as sandy beach.

Physically, this shoreline is quite uniform from Pt. Conception to Santa Barbara Harbor. The beach is narrow and sandy, backed by low cliffs and bluffs. Occasional rocks punctuate some stretches of this beach.

Between Pt. Conception and Gaviota, the coast is privately owned and largely inaccessible except by boat. Uplands are generally not developed. Gaviota State Park is the only developed recreation site in this reach. This park is located where the westerly progress of U.S. Highway 101 terminates as it turns inland and north.

TABLE II-55

INVENTORY OF OUTDOOR RECREATION AREAS
AND SELECTED FACILITIES - SUMMARY

SANTA BARBARA COUNTY

Categories	Area	Existing sites	Units
Playfield	224	58	
Swimming beach	101*	9	
Picnic	197	167	1,802 tables
Boat access parking	0	1	150 spaces
Tent camp	287	192	1,073 "
Trailer camp	69	59	262 "

*includes inland and ocean

Total Acreages

Land Types	Land Acres	Wetlands	Water	Total
	831,891	2	29	831,922

BOR Land Classes	Class I AC	Class II AC	Class III AC	Class IV	Class V	Class VI
	529	549	756,032	5	74,468	101

Annual Attendance	Day-1959	Nite-1959	Total-1959	Day-1969	Nite-1969	Total-1969
	2,082,220	116,600	2,198,820	5,544,213	470,125	6,014,338

Source: California Department of Parks and Recreation, Summary Printouts 1969 (Feb. 1971).

From Gaviota State Park to Coal Oil Point, the shoreline is mostly privately owned and largely undeveloped. Oil derricks and tank farms occupy the eastern portion of the area. Between Coal Oil Point and Santa Barbara Harbor, approximately half of the shoreline is privately owned and the remainder is mostly state land. Much of the upland is developed to some degree.

State Park System

Gaviota State Park

Gaviota State Park has scenic, historic, scientific and recreational values. This park includes 5.4 miles of coastline and extends inland for about 3 miles in a $1\frac{1}{2}$ mile wide strip which encloses a total of approximately 2800 acres. Upland portions of the park contain many typical ecological communities consisting of coastal sage, chaparral, oaks and sycamores. These communities are to be preserved and upland development will be restricted as a result. Limited beach area will restrict the availability of recreation opportunity to about 500 people at one time. Behind the beach there are 59 camp units, 29 picnic tables and 75 beach parking sites. This provides a potential beach visitation of 834 (California, 1972).

$$59 \times 8 = 472$$

$$29 \times 3.5 = 101 \text{ ((101.5) should be rounded to 102)}$$

$$75 \times 3.5 = \underline{261} \text{ ((262.5) was "261" in original report)}$$

$$\text{*Total} \quad 834 \text{ (836 if added literally)}$$

Figures updated from FY 1972-3 Stat. Report

In 1972, the potential beach visitation was 820 people and this figure was being reached on busy weekends. Overflow was being

accommodated at the fishing pier and at isolated portions of the beach downcoast (Calif. 1972).

The visitation in 1969-70 F.Y. totalled 112, 512 (Calif., 1969-70) rising to 128,291 in 1972-73 F.Y. (Calif. 1972-73).

Scenic values are rated as high for the most part. Ocean vistas, including the offshore islands are important features. Identified unesthetic elements include the railroad right-of-way with its trestles, wires and poles, along with tanks, buildings, and other facilities constructed by oil companies along this coast (Calif. 1972).

Abundant evidence of Indian villages exists primarily along the mouths of larger streams. Cabrillo is known to have anchored here in 1542. Portola camped near or at this beach in 1769. Gaviota Pass was a principal pass dating from Spanish times and as such, functioned prominently in the early history of the region.

Recreation activities in the park include surf fishing. Sportsmen all fish from the pier at the mouth of Gaviota Creek and embark from there on deep sea party boat fishing trips. Swimming, sunbathing, surfing, picnicking, beachcombing and sightseeing constitute the beach activities. Inland activities are primarily hiking and horseback riding. Sightseeing and natural history study are the corollaries to hiking experiences in this park.

Expansion of Gaviota State Park in all four directions with beach acquisition sufficient to connect this park with Refugio State Beach to the east would be desirable, according to the State of California.

Refugio and El Capitan State Beaches

Eastward 6 to 10 miles of Gaviota, are Refugio and

El Capitan State Beaches. These parks lie between the ocean and the Southern Pacific railroad track. The beach is relatively narrow and small portions of it are totally inundated at high tide. While lacking individually spectacular features, these parks have a peaceful charm and serve to maintain public access to this beautiful section of coast.

Historically, these parks are important. The whole coastal plain and adjacent canyons from Santa Barbara to Pt. Conception have played an important part in the early Spanish exploration and settlement of California.

Juan Rodríguez Cabrillo anchored near this coast in the fall of 1542. While in the vicinity he replenished wood and water supplies.

Sebastian Vizcaino entered the Santa Barbara Channel on Dec. 4, 1602, naming the passage after the saint whose feast fell upon that day.

Two Spanish landgrants comprised the original European ownership of this area. Some of the earlier adobes built on these grants still remain.

Many expeditions passed through the area including those of Gaspar de Portola, Pedro Fages, Junipero Serra, and Juan Bautista de Anza. Many padres used this trail communicating between Mission Santa Barbara and Mission Santa Ines.

Archaeological values exist both within and near the park lands. Little work has been done in studying these sites.

El Capitan State Beach covers 133 acres containing 85 camping units and 30 picnic units (Calif. 1972-73). Refugio State Beach has 90 acres with 85 camping units and 60 picnic units.

Visitor attendance at El Capitan rose from 209,378 in F.Y. 1969-70 to 278,283 in F.Y. 1972-73 (Calif. 1969-70, 1972-73). Attendance at Refugio was 131,033 in F.Y. 1969-70, rising to 137,270 in F.Y. 1971-72 and falling to 104,160 for F.Y. 1972-73. During this time, park acreage was increased but the number of camping units was reduced from a high of 111 in 1969 to 85 in 1972 (Calif. 1969-70, 1971-72, 1972-73). Part of the decline may have been due to the reduction in available facilities and part due to the weather being cooler than normal during the summer of 1973. This reduced pressures on beaches all along the coast.

The remaining state installation is Carpinteria State Beach at Carpinteria. This beach park has a total of 50 acres in it with an ocean shore of 4100 ft. Picnic facilities number 103, and 125 camping units are provided. Visitor attendance for the 1972-73 F.Y. was 337,372 (Calif. 1972-73).

State owned sites are made available for operation by federal or local agencies in some cases. Goleta S.B. is operated by the Santa Barbara County Park Department.

Total pertinent figures for state owned and operated units within the studied portion of the Santa Barbara County Coastal area are:

<u>Park Acreage</u>	<u>Oceanfront</u>	<u>Family Units</u>		<u>1972-73 FY Visitation</u>
		<u>Camping</u>	<u>Picnicking</u>	
3046	55135 ft	354	222	811,124

County Parks

Santa Barbara County Park Department operates several facilities along the south coast. These are Goleta State

Beach, Arroyo Burro Beach, Lookout, Carpinteria Beach West and Rincon Beach.

Goleta State Beach

Located just east of Goleta Point, this beach is state-owned and county operated. Total acreage is 24 with 14 acres of beach. There are 20 picnic and no overnite units. Visitation in 1969 was 183,480.

Arroyo Burro Beach

This beach is located on the west side of Santa Barbara and is 5 acres in size. Day use facilities include 5 picnic units. Visitation in 1969 was 292,508.

Other Beaches

Other beaches are located at Montecito, Carpinteria West and Rincon Pt.

Local, Private and Miscellaneous

A varied assortment of recreational facilities such as fishing piers, boat facilities, wildlife refuges and locally operated beaches exists primarily in the City of Santa Barbara area.

Beginning just west of Coal Oil Point, at Ellwood, there is Ellwood Pier and Devereux Slough. The University of California at Santa Barbara occupies Goleta Point and provides a beach which is not open for general public use. Continuing easterly, there is the airport wildlife preserve located near the Santa Barbara Airport and Hope Ranch private beach park. In the Santa Barbara municipal area beachfront, there are the following sites: Shoreline, Leadbetter,

Pershing, La Mesa and Palm Parks; Cabrillo and Miramar Beaches; Andre Clark Bird Refuge and Child's Estate. Private Parks are the Santa Barbara Shores Beach Club and El Descandero Park. Farther east, at Carpinteria is the Sandyland Wildlife Preserve.

Federal Parks

Channel Islands National Monument includes 3 islands collectively called Anacapa Island which is in Ventura County and Santa Barbara Island which is in Santa Barbara County. This national monument was established in 1938 primarily for its unusual geological features and unique plant and animal life. Recreational use has grown in recent years to the point where management to protect the ecological values has become imperative.

Recreational facilities exist at both Anacapa and Santa Barbara Islands. At Anacapa there are anchorages at Cat Rock, Frenchy's Cove, East Fish Camp and the landing cove at East Island. No piers or mooring facilities are maintained so anchorage may be unsafe under adverse sea conditions and skiffs are needed to make landings. Day-use facilities consisting of pit toilets and picnic tables exist at Frenchy's Cove and at East Island. Camping is primitive and restricted to East Island. All supplies including water and fuel must be brought in by the camper.

Santa Barbara Island is 42 miles (68 km) from the mainland coast and is roughly 1 square mile (2.6 km²) in area. There is an anchorage at the landing cove on the northeast side of the island. This anchorage, like those at Anacapa, is uncertain and it is recommended

that boats not be left unattended. Camping is primitive, as on Anacapa, and is restricted to the area of the quonset hut.

Recreational attractions include the isolated island environment, hiking, unique ecosystems (discussed in section II.F.3.), spectacular scenery, diving and fishing in the magnificently lucid surrounding waters and boating near the islands. Archeological values exist on these islands but neither salvage nor interpretation has been undertaken.

In the past, patrols were made irregularly and park personnel were resident occasionally in the monument. Under these circumstances, accurate visitor data was difficult to obtain. Presently, patrols are made much more frequently and NPS personnel are resident on the islands. The use estimates were made by using the following parameters:

Total visits are the sum of the following items.

a. Total number of persons debarking from boats onto Anacapa Island, estimated by actual physical counts at French's Cove by National Park Service personnel seasonally resident on the island or by reports from Island Packer Cruises.

b. Number of persons aboard boats within a nautical mile of Anacapa and Santa Barbara Islands, except boats known to be bound for Fenchy's Cove shall not have their passengers counted again.

c. Effective January 1, 1968, the number of persons debarking from boats onto San Miguel Island as estimated from actual physical counts by Service personnel is to be added to the total.

Approximately two-thirds of the total visits are day use only. It has been estimated that this segment of the total visitation spends an average of 6 hours in the monument, though they may not set foot on the islands.

A distinction has been made between overnight stays on the shore as opposed to privately owned boats. A rough estimate suggests that boat "camper" numbers are normally at least double their shoreline counter-parts.

Monthly totals for the past 3 years are as follows:

	<u>1967</u>	<u>1968</u>	<u>1969</u>	<u>1970</u>
January		1246	1516	596
February		1159	320	470
March		1012	111	845
April		1476	1942	760
May		1848	1952	
June		3367	4040	
July	4750	3443	6159	
August	4293	6124	6790	
September	2168	4834	5648	
October	1626	2752	1900	
November	1386	2174	1000	
December	<u>1510</u>	<u>1575</u>	<u>700</u>	<u> </u>
	15,733	31,010	33,078	32,047

NPS, 1970, Basic Data: Channel Islands, unpublished.

The preceding monthly breakdown indicates the timing of use throughout the year. Subsequent annual visitor totals follow:

<u>1971</u>	<u>1972</u>	<u>1973</u>	<u>1974</u>
30,886	41,610	54,034	34,526*

*Through September.

Visitation figures probably underestimate the number of people using the surrounding waters without going ashore. The monument includes those waters within one nautical mile of shore.

Use of the islands has reached the limit of their carrying capacity and visitor restrictions will probably be necessary. Increased use will necessarily have to take place in the surrounding waters.

Proposed Addition

Several proposals have been made to include all of the northern Channel Islands into a sea dominated national park. None of these proposals has come to fruition, as yet. If this National Park is established, it will immensely expand the recreational opportunities available to the people of the area and the nation. The resource presented by this proposed park is, perhaps, unparalleled anywhere in the world with so wide a variety of marine mammals available close to as large a concentration of people.

San Miguel Island

The westernmost island, San Miguel, is under Navy administration with joint management of surface resources by the Department of Interior. The island comprises 14,000 acres, most of it

122-152 meters (440-500 ft.) in elevation, reaching a peak of 253 meters (831 ft.). It has 38.6 km (24 miles) of coastline, most of which is bold rocky bluffs. Short stretches of sandy beaches and pocket beaches total about 10 km (6 meters.). Several landings and anchorages are available although the Navy ordinarily prohibits landings. There are abundant archeological and paleontological values present. Rookeries of sea birds and pinnipeds are present. The sea elephant colony is one of the largest known. Wildflower displays are prominent in spite of grazing and erosion. Archeological values are present and present an interpretive as well as a valuable cultural resource. San Miguel is most valuable for its natural history resources rather than for its recreational activity values such as hiking or camping.

Santa Rosa

Santa Rosa is privately owned, about 16 km (10 miles) wide by 24 km (15 miles) long and comprises 55,000 acres. The shoreline extends 70 km (44 miles) and varies in character from high rocky bluffs to low sand spits. Sand dunes occur near the western end of the island. Sandy shores occur over about 19 km (12 miles) of the coast. The interior is mountainous extending to elevations of 484 m (1589 ft). Most of the vegetation is grassland accented occasionally by shrubs and a few trees. The island is used for grazing with a small area in cultivation. Abundant archeological resources are present.

Potential recreational uses are numerous. A few are boating, fishing, diving, picnicking, hiking, camping and exploring. Unique ecological assemblages exist which lend themselves to interpretive

opportunities for both the casual and serious ecologist.

Santa Cruz

Santa Cruz is the largest of the islands and it, like Santa Rosa, is privately owned and used for ranching. Ninety-seven kilometers (60 miles) of shoreline enclose the 62,000 acres of this island which is roughly 8 km (5 miles) wide and 34 km (21 miles) long. The shore is bold, steep and rugged, gashed with numerous points and indentations and punctuated by sea coves. There are plentiful anchorages, harbors and landings and approximately 10 km (6 miles) of sandy shorelines exist in pocket beaches and harbors. Numerous peaks occur on the island, with the highest reach 732 m (2400 ft) and several extending above 518 m (1700 ft). Topography is varied and interesting as is the vegetation. This island is the most densely wooded of the northern islands, presenting a park-like atmosphere of wooded groves interspersed with open grass and brushlands. Unique plant and animal communities exist. Marine life abounds with good representation of invertebrates, fishes, marine grasses, kelp and other algae. This island, like the others, possesses bounteous archeological values.

Recreation attractions include the spectacular scenery, sea coves, fishing, diving, swimming, hiking, camping, and natural history study. Current land use is ranching with some cultivation. Public landings are prohibited without the owner's permission.

Incorporation of the preceding three islands with the existing two islands of the National Monument into a new National Park would

radically alter recreation opportunities available in the Bight region. Use is now restricted to the small islands of the National Monument and to the waters surrounding the larger islands. With the establishment of a five island National Park, 1980 use is expected to reach 400,000 to 600,000 recreation days (BOR, Memo 1973).

All of the northern islands are within Santa Barbara County jurisdiction with the exception of Anacapa Island, which is in Ventura County.

Boating Facilities and Use

Boating comprises a major portion of the Santa Barbara area's recreation mix. Both sail and powered craft are used as well as small skiff types. Sports fishing utilizing both private craft and party boats is common. Sports fishing is covered in greater detail elsewhere in this section.

Launching facilities are available at Gaviota and both rental and launching are available at Goleta. The major facilities are in Santa Barbara Harbor where a large marina and slips are available. Launching and rentals are also available in the harbor. Party boats and private craft land their sport fish catches in this harbor. There are presently 782 slips available in the harbor of which approximately 175 are utilized by commercial fishing vessels. Waiting lists for slips currently entail a 3-4 year wait. Construction is proposed to commence in November which will provide an additional 350 slips.

Twelve visitor slips are maintained with stays limited to 14 days.

The destination of the majority of the permanent boaters is the waters surrounding Santa Cruz Island.

Recreational use comprises an important part of the Santa Barbara environment. While much of the recreational use comes from the local population, Santa Barbara's south coastal recreational sites are within one to four hours of Los Angeles Metropolitan Population Center. Consequently, weekend pressure comes from the Los Angeles area. The BOR (1973) estimates a total visitation of over two million people for state, county and city ocean-front parks in Santa Barbara County.

Ventura County

Ventura County, as befits its location, is transitional between Santa Barbara County and populous Los Angeles County. Santa Barbara County is cooler, more pastoral and is growing more slowly. Ventura County is growing rapidly and sustains far greater impact from the Los Angeles area on its resources than does Santa Barbara County. Although still largely rural, urbanization is spilling from the San Fernando Valley to Ventura County. Much of the County's coastline is readily accessible both to local residents, as well as to the Los Angeles Metropolitan area. The total length of the shoreline is 66 km (41 miles) most of which is sandy beach. Steep bluffy terrain is found on the county's northern coast and some cliffy terrain is found on the southern coast. Much of the back-shore has some development.

Beginning at Rincon Point and going 25 km (16 miles) to the City of San Buenaventura (Ventura), there are 15 km (9.4 miles) of

publicly owned and 10 km (6.4 miles) of privately owned shoreline. Public recreational use occurs on 11 km (7 miles) while private recreational use occupies less than 1 km (0.5 mile). Non-recreational development utilizes 12 km (7 miles), while 1.7 km (1 mile) remains undeveloped. The beaches are narrow and sandy or cobbly. A total of 24 km (15 miles) is classified as sandy. At high tide some of these beaches are covered. U.S. Highway 101 closely parallels the ocean in most of this reach. The northern portion of this shoreline has several offshore and onshore petroleum installations. All of the publicly owned land is either owned by recreational agencies or by the State Department of Transportation.

Living and non-living resources of this coastal reach are: tide pools, kelp beds, shoreline biotic communities, scenic vistas and archeological sites. Recreational activities include surfing, fishing, camping, beach strolling, picnicking and scenic driving.

The Ventura County Coastal Study (Ventura County, 1974) policies for this region include that of preserving the character of the North Coast through the protection of designated environmental and cultural resources.

The next regional breakdown extends from Ventura to Point Mugu and covers 29 km (18 miles) all of which is classified as sandy beach. Public ownership involves 26 km (16 miles) of shoreline including 11 km (7 miles) which is within the Point Mugu and Port Hueneme Naval Reservations. There are 3 km (2 miles) of private land which are used for private recreation. Public recreational use occurs on 13 km (8 miles). Non-recreational development has taken place on 2 km (1 mile)

while 11 km (7 miles) remain undeveloped.

Backshores consist of the Oxnard Plain which is a lowland sand dunes, wetlands and some development. Urban development exists at the northern end of this reach within the City of San Buenaventura and at the south at the City of Oxnard and the unincorporated communities of Hollywood by the Sea and Silver Strand. Lagoons exist at the mouth of the Santa Clara River and Mugu Lagoon at Point Mugu. Planning efforts for this reach are mostly within city jurisdictions.

The final segment of Ventura County coast extends from Pt. Mugu to the Los Angeles County line at Leo Carrillo State Park. Total length of this segment is 12 km (7.5 miles) of which 5 km (3 miles) are publicly owned and 7 km (4.4 miles) are privately owned. Public recreational use occurs on 5 km (3 miles) with private recreational use occurring on 0.5 km (0.3 miles). Non-recreational development exists on 0.6 km (0.4 mile) with 6 km (3.7 miles) remaining undeveloped. Almost all of this beach is sandy, ranging in width from 30 m (110 ft) to 90 m (300 ft) and backed by low bluffs and containing occasional small rocky protrusions. Backshores contain the Coast Highway, scattered groups of residential development and grades into the western end of the Santa Monica Mountains.

Recreation's dominant use of the Ventura County shoreline is demonstrated in the following table; II-56.

Summary of Ventura County Shoreline Use

<u>Category</u>	<u>Km</u>	<u>(Miles)</u>
Public Recreational	18	29
Private Recreational	4	3

TABLE II-56

INVENTORY OF OUTDOOR RECREATION AREAS
AND SELECTED FACILITIES - SUMMARY

VENTURA COUNTY

Categories	Area	Existing sites	Units
Playfield	428 acres	84	
Swimming beach*	231 "	10	
Picnic	432 "	175	2292 tables
Boat access parking	91 "	4	400 spaces
Tent camp	347 "	134	1302 "
Trailer camp	49 "	7	557 "
Marina	302 "	2	180 slips

*All ocean

Total Acreages

Land Types	Land Acres	Wetlands	Water	Total
	535,705	0	18,453	554,158

BOR

Land Classes	Class I AC	Class II AC	Class III AC	Class IV	Class V	Class VI
	248	2,110	450,444	2,000	500	8

Annual

Attendance	Day-1959	Nite-1959	Total-1959	Day-1969	Nite-1969	Total-1969
	1,817,102	8,260	1,825,362	7,030,803	1,006,100	8,036,903

Source: California Department of Parks and Recreation, Summary Printouts 1969 (Feb. 1971).

<u>Category</u>	<u>Km</u>	<u>(Miles)</u>
Non-Recreational Development	14	9
Undeveloped	18	12
<u>Ownership</u>		
Public	46	28.5
Private	<u>20</u>	<u>12.7</u>
Total Shoreline	66 Km	(41 miles)

State Parks

There are four State Park Units within the Ventura County coastal area. Funding has been assured by voter approval of the 1974 Park Bond Act, for a proposed addition to the Leo Carrillo State Beach within Ventura County.

Emma Wood State Beach

Emma Wood State Beach lies just west of the City of Ventura between the Southern Pacific tracks and the ocean. This narrow beach has 101 acres of land with 440 m (14,440 ft) of ocean frontage. Camping for 200 families is available next to an abandoned section of highway. At high tide, the beach is inundated but several small tide pools are available at low tide.

Major recreational activities available are camping, picnicking, swimming, surfing and fishing. Bird life is abundant and there is a small freshwater marsh at the southwest end of the beach which attracts small rodents, raccoons, song birds and red-tailed hawks. Gray whales can be seen from the beach when they are migrating. Visitor attendance

was 84,761 for the 1972-73 F.Y. coming down from a high of 101, 747 in 1971-72 F.Y.

San Buenaventura State Beach

Providing ocean oriented recreation opportunity within the City of Ventura, this beach offers picnicking, swimming, surfing, fishing and birdwatching. A total space of 116 acres is available which includes an ocean frontage of 355 m (11630 ft). A 518 m (1700 ft) fishing pier offers opportunity to take bonita, surf perch, shark, bass and corbina. Partakers of that great Southern California sport of grunion hunting may indulge themselves at this beach when the runs occur in March, June, July and August. One-hundred sixty-five picnic tables are available but no overnight camping. Future expansion may include 115 campsites by 1980. Many upland and shorebirds add to the enjoyment of visitors.

Visitation was 727,743 in 1972-73 F.Y. down from a high of 909,761 reached in 1969-70 F.Y.

McGrath State Beach

Located at the western city limits of Oxnard, this 295 acre park provides 318 m (10,445 ft) of ocean frontage. Facilities include 174 campsites. Expansion at McGrath is expected to result in 575 campsites by 1980.

Sunbathing and fishing for bass, corbina and perch are some of the activities available at the park. Although lifeguards are on duty during the summer, swimming is not recommended because of strong currents and riptides.

The park includes the wetlands of the Santa Clara River's mouth in its northern boundary and a small body of water, McGrath Lake, in its southern end. Numerous small mammals including weasels, muskrats, skunks, jackrabbits, opossum, squirrels and reptiles such as tortoises and gopher snakes are found in the river wetlands and surrounding uplands area. McGrath Lake attracts in excess of two hundred bird species, including white-tailed kites, marsh and red-tailed hawks, owls and herons. Rare birds, including ospreys, white wagtails and black skimmers, have been reported there also.

Visitation was 106,493 in the 1972-73 F.Y. down from a high of 114,287 reached in the 1969-70 F.Y.

Point Mugu State Park

A large park containing over 9000 acres of beach and upland Santa Monica Mountain area, Pt. Mugu State Park offers a wide variety of vegetation and environmental variety.

Camping is available at 100 units and picnicking may take place at 50 developed units. Expansion will provide a total of 710 campsites by 1980.

Swimming, sunbathing, fishing and surfing take place from the 60 acres of beach which is washed by 586 m (19,224 ft) of the Pacific. Pt. Mugu State Park is included in landscape preservation projects along with McGrath Lake. Included with the Pt. Mugu State Park proposal are total of 11 km (7 miles) of beach, several geologic features and numerous biotic communities.

Visitation was 210,713 in the 1972-73 F.Y. down from a high of

264,554 reached in the 1971-72 F.Y.

Beach attendance for the four State Beaches in Ventura County has averaged 1,184,679 over the years 1970 through 1973. High attendance of 1,321,149 occurred in the 1969-70 F.Y. and the low was reached in the 1971-72 F.Y. at 1,106,300. The low attendance last year was probably related to weather as the 1973 summer was unusually cool and more frequently overcast.

County Parks

There are no state owned, county operated parks in the county. Hobson (1.8 ac) and Faria (1.5 ac) Parks are two small sites located on the coast north of the City of Ventura. Neither park contains beach oriented recreation. Visitation for Faria Park was 90,775 and 135,940 for Hobson Park in 1971 (BOR Memo, 1973).

Within the City of Ventura, the County Fairgrounds and associated beach park offer ocean recreation opportunities.

Hollywood and Silverstrand Beaches lie in the Oxnard area and receive heavy use from that metropolitan area. Hollywood beach has a total of 53 acres of beach while Silver Strand has a total of 41 acres. Visitation in 1969 was 685,850 for both beaches, falling to 663,700 in 1971 for both parks. Parking problems exist at both beaches, hindering their effective use.

Local, Private and Miscellaneous

Ventura marine beaches are operated by the City of Ventura. Oxnard owns, the as yet undeveloped, Oxnard Shores Park and operates the beach within county owned Channel Islands Marina.

The city also has plans to develop Osmond Beach in the future.

The City of Port Hueneme operates the Port Hueneme City Beach Park, a 50 acre site containing a public fishing pier and other major recreational facilities. This is the largest park in the city and attracts people from the regional area as well as from the City of Port Hueneme. There are 30 acres of beach for swimming and sunbathing. Picnic facilities and children's play equipment are available.

Visitation was 500,000 in 1969 and 350,000 in 1971.

In addition to the developed sites within the county, there are many miles of public and private beach areas which are used by the public. Loss of these unofficial resources through such actions as closure of private lands used for beach access will have damaging effects on regional recreation opportunities. For example, since 1941, undeveloped county shoreline has decreased from over 30 miles (48 km) to less than 8 miles (12.9km). To be sure, as the available undeveloped shoreline continues to decrease, competition between public and private interests will further intensify, adding to the pressures and conflicts already existing (Ventura County, 1974).

The Ventura County Coastal Study 1974 notes a statement by the County Parks Commission:

"The singularly most unique recreational feature of Ventura County is its long Pacific shoreline. Few coastal counties in California have more miles of beaches suitable for boating facilities, day and overnight camping, fishing, clamming, surfing, and general play use. Without doubt, the Ventura coastline is the county's outstanding recreational resource."

In recognizing the value of its coastal resource, Ventura County sees ever increasing demands on that resource:

"During 1972-73, the number of visitors to the County Beach Parks was about 929,000. With the demand for outdoor recreation opportunities in the County increasing, as a result of a general increase in population, mobility, affluence, leisure time and environment appreciation, the amount of area open for public recreation to satisfy the demand also needs to increase, especially near the shoreline. For Ventura County, the increasing demand for coastal public recreation opportunities will be especially great because of its close proximity to the Los Angeles Metropolitan Area (Ventura County, 1974)."

Boating Facilities and Use

Ventura Marina, located in the City of Ventura, is owned by the Ventura Port District. Within the marina, the Ventura Yacht Club has 57 slips and the Ventura Isle Marina has 507. The predominant destination for most of the users is the Channel Islands area.

Channel Islands Harbor is located in Oxnard and is owned by the Ventura County Department of Airports and Harbors. It occupies an area of 313 acres, of which 83 acres are land and 230 acres are water. Facilities include public beaches, public launching, boat repair, restaurants and parking. Approximately 600 slips are presently available with potential for an additional 1200-1800. Charter trips to Channel Islands National Monument are available from the Harbor. The destination of most private boaters is the Channel Islands.

There is a small craft harbor within the commercial harbor of Port Hueneme.

Los Angeles County

Los Angeles County is pivotal in any discussion of recreation in Southern California. Overwhelmingly first in population

of the five counties studied and second only to San Diego County in physical size, L.A. County has a profound impact on the region's recreation. Many of the County's recreation needs are satisfied within its boundaries which enclose a diversity of values ranging from San Clemente Island some 88 km (55 miles) offshore from L.A. Harbor, to portions of the Mojave Desert. In between, lie the forested ranges of the San Gabriel Mountains in the Angeles National Forest. Although generously endowed with recreation resources, the population is so large that the available resources are largely inadequate. Demand for day use facilities is particularly acute. Typical one day recreation use occurs within two hours travel time of the urban area. Weekday, holiday and most of the weekend demand is concentrated within one hours' travel. Nearly 41% of total recreation participation occurs within the one hour travel zone with nearly 55% of the total recreation participation occurring within the two hour travel zone (CORRP, 1972). Two hours' travel places the entire coastline from San Diego to Santa Barbara within reach of the L.A. Metro Area. The most intense use is concentrated at the closest beaches, those being on the Santa Monica Bay shoreline between the City of Santa Monica and the City of Redondo Beach. Attendance there on a hot Sunday in July 1974 was estimated to be 500,000 persons. Total Los Angeles and Orange County beach attendance on that same day was estimated at 1,261,000 persons.

The Corps of Engineers, in the *National Shoreline Study*, (1971) credited mainland Los Angeles County with a shoreline length of 119 km

(74 miles), exclusive of the Harbor. Public recreational use occurs on 46 km (35 miles of shoreline while private recreational use utilizes 34 km (21 miles) A total of 83% of the Los Angeles shoreline is thus used for recreational purposes.

Table II-57 shows the ownership, use and characteristics of the county's shorelines.

Table II-57
L.A. County Shoreline
Ownership-Use-Sandy Beach

Area	Ownership		Use				Sandy Beach
	Public	Private	Public Rec.	Pvt. Rec.	Non-Rec. Develop.	Un-Develop	
Los Angeles County	37.8 mi (61 km)	30.1 mi (48 km)	34.9 mi (56 km)	21.2 mi (34 km)	0.3 mi (0.2km)	11.5 mi (18 km)	50.3 mi (81 km)
L.A. Harbor	20.1 mi (32 km)	9.9 mi (16 km)	--	--	30.0 mi	--	0.5 mi
Catalina Island	--	50.0 mi (80 km)	1.6 mi (3 km)	1.3 mi (2 km)	0.2 mi (0.3km)	46.9 mi (76 km)	5.5 mi (9 km)
San Clemente Island	--	--	--	--	--	50.0 mi (80 km)	2.0 mi (3 km)

Non-recreational development ties up only a small segment of the shoreline and a limited amount of undeveloped shoreline remains.

Beginning with the L.A.-Ventura county line at Sequit Point, and progressing easterly to Point Dume, the shoreline is sandy beach backed by low cliffs. About 50% of the backshore is developed, largely with residential structures. Approximately 73% of the shoreline is privately owned. Land available for public recreation lies within Leo Carrillo and Point Dume (Westward Beach) State Beaches, Zuma County Beach and Nicholas and Trancas private beaches.

Leo Carrillo State Beach is 1578 acres in size and contains 2011 m (6597 ft) of ocean frontage. There are parking facilities and beach on the ocean side of the Coast Highway and a campground containing 140 family units in a canyon north of the highway. Much of the park is upland area containing representative flora and fauna of the Santa Monica Mountains. Park activities include swimming, surfing, skindiving, picnicking, camping and hiking. Pelicans, gulls, grebes, black brants and cormorants may be seen, as well as occasional seals, sea lions and gray whales. Attendance was 395,825 in F.Y. 1972-73 down from a high of 556,185 reached in 1971-72 F.Y.

Point Dume State Beach is operated by the L.A. County Department of Beaches. It contains 30 acres of state owned land and 1356 m (449 ft.) of ocean frontage. Activities include swimming, surfing and diving.

The segment from Point Dume to Santa Monica Pier consists of sandy beaches, narrower at the western portion and becoming wider to the east. The backshore is mostly developed with residences. The coastal strip is narrow and the Coast Highway is close to the ocean because the steep slopes of the Santa Monica Mountains crowd the shore in this stretch, falling back only near the City of Santa Monica.

Seventy percent of this coastal reach is privately owned. All of the publicly owned land is utilized for public recreational purposes.

Topanga Beach is the only state owned and operated beach within this segment. Located near the foot of Topanga Canyon Blvd., this recent acquisition (1973) includes 31 acres.

Will Rogers State Historic Park is on a bench less than 2.9 km (1.8 miles) from the beach. This park preserves the home of the famous humorist and provides riding and hiking trails, as well as a polo field. Abutting Will Rogers SHP is the 4145 acre Santa Monica Mountains State Park. This park consists of 2445 acres of state owned land and 1700 acres of lease or permit land. Values in this park include representative Santa Monica Mountain ecosystems and vistas.

There are four units of the State Park System, in this stretch, which are operated by L.A. County and two cities. These parks are Malibu-Surfriders, Las Tunas, Will Rogers, and Santa Monica State Beaches.

Malibu-Surfrider (Malibu Lagoon SB) is located at Malibu Pt. and operated by Los Angeles County. This park has 52 acres and 900 m (2950 ft) of ocean frontage.

Las Tunas State Beach is operated by Los Angeles County and consists of 2.4 acres with 476 m (1560 ft) of ocean shore.

Will Rogers State Beach is located in several discontinuous segments between the western city limit of Los Angeles and Santa Monica. It is operated by the Los Angeles City Department of Recreation and Parks, contains 66 acres of land and has 2962 m (9715 ft) of ocean frontage.

Santa Monica State Beach is located on the Santa Monica City waterfront and is operated by that city. This park offers 46 acres of sandy beach and parking along with 2998 m (9833 ft) of ocean shore.

Palisades park lies just inland of the Coast Highway in Santa Monica and can be considered part of the coastal environment. The park is 26 acres in size, includes picnic facilities and some very

picturesque bluffs.

Corral-Solstice Beach is located midway between Pt. Dume and Malibu Pt. It contains 4 acres of beach and is operated by the County.

In addition to the public beaches, there are beaches in the intervening areas which are privately used. Although the beach itself is public property, access is precluded by blocked up private ownership of the backshore. As a result, private use of the beach ensues. For purposes of this analysis, this entire coastal reach can thus be considered to be relegated to recreational use.

Beginning at Pt. Dume, the following beaches are primarily privately used:

- Paradise Cove
- Escondido Beach
- Puerco Beach
- Amarillo Beach
- Malibu Beach
- Carbon Beach
- La Costa Beach
- Big Rock Beach

The next segment encompasses the southern shore of Santa Monica Bay extending from the Santa Monica Pier to the beginning of the Palos Verdes Peninsula. Beaches are wide and sandy and heavily used, being the most readily reached sites from the inland metro region. The backshore is almost totally developed and is primarily residential. One small segment at El Segundo is developed with an oil refinery and power plant. Nearly all of the beaches are devoted to recreation. Twenty-five kilometers (16 miles) of this reach are publicly owned and devoted to recreational uses while the remaining 0.8 km (0.5 mile)

is privately owned and likewise devoted to recreational uses.

Beach erosion has created some problems for beaches in this segment. As an example, Dockweiler State Beach has required emplacement of some 19 million cubic yards of material since 1938 for maintenance purposes (U.S.C.O.E., 1971). Redondo Beach has also required stabilization structures to protect emplaced fill.

There are no state operated units of the state park system in this segment of the coast. The county and local jurisdictions operate several State Beaches.

Los Angeles County operates Manhattan State Beach, Redondo State Beach, Clifton and Torrance beaches.

Manhattan State Beach is located on the waterfront of the City of Manhattan Beach. It contains 44 acres and 3338 m (10,950 ft) of ocean frontage.

Redondo State Beach is located on the Redondo City waterfront, contains 26 acres and 2143 m (7030 ft.) of ocean frontage.

Clifton Beach lies south of Redondo Beach Park, extending to the south city limit of Redondo Beach.

Torrance Beach Park lies on the City of Torrance waterfront and includes 10 acres of beach and 5 acres of parking.

Local or city operated beaches complete the recreation picture in this segment. Beginning at Santa Monica Municipal Pier, Santa Monica State Beach, extends south of the pier to Ocean Park Pier and the south city limit.

Venice Beach is on the waterfront of the community of Venice. It is operated by the City of Los Angeles and includes 60 acres of beach

within its 196 acres.

Dockweiler State Beach begins at the north and south jetties of Marina Del Rey Harbor and extends southerly through El Segundo in a discontinuous strip. Operated by City of Los Angeles, this park contains 140 acres of swimming beach with a total ocean frontage of 3459 m (11,346 ft).

El Porto Beach lies on the northern waterfront of the City of Manhattan Beach.

Hermosa Beach Park lies within the City of Hermosa Beach and includes 46 acres of beach within its total of 60 acres.

The City of Redondo Beach lists a total of 4 acres of swimming beach for two areas, Redondo Beach and King Harbor-Dominguez.

The next segment considered, extends from the northern Palos Verdes Peninsula at Malaga Cove to the San Pedro Breakwater. This 27 km (16.8 miles) reach includes rocky cliffs and headlands with pocket beaches of sand or cobbles. The backshore is a series of prominent marine terraces. Development is residential for the most part, and clustered with a great deal of interspersed open space. Non-residential developments include the Point Vicente and Point Fermin Lighthouses, Fort MacArthur Military Reservation and Marineland commercial aquarium.

Fifty-nine percent of the shore is privately owned of which 10% is used for recreational purposes. A total of 11 km (6.9 miles) is publicly owned with 7 km (4.3 miles) being used for recreational purposes. Undeveloped shoreline exists for 19 km (11.5 miles) of

the segment.

County parks include the fishing access at Point Vicente and Palos Verdes Shoreline Park. The fishing access is 10 acres in size and provides a road to the beach from the bluffs. This park also provides a panorama of Catalina Island and the Palos Verdes Peninsula Shoreline. Palos Verdes Shoreline Park has a total of 53 acres and provides a similar panoramic view to Pt. Vicente Park.

Royal Palms State Beach is under Los Angeles City administration and is 18 acres in size. The park has 1426 km (4678 ft) of ocean frontage and offers its visitors a panorama of Catalina Island and the Palos Verdes Peninsula shoreline.

Point Fermin Park is administered by Los Angeles City and is 37 acres in size. The park offers shoreline access and views of Catalina Island and the Palos Verdes Peninsula. Visitation in 1969 was 122,050.

Cabrillo Beach Park is 54 acres in size and located at the root of the San Pedro (West) Breakwater. It is managed by the City of Los Angeles. Although a large part of this shoreline is privately owned, most of it has been available to the public.

Los Angeles Harbor comprises the next segment of shoreline. The Harbor contains 32 km (20 miles) of publicly owned shoreline and 16 km (10 miles) of private ownership. The bulk of the shorelines' 48 km (30 miles) is developed for non-recreational purposes. Only 0.8 km (0.5 mile) of shoreline is considered as sandy beach. Although a commercial harbor facility, recreational use does come from the various marinas and embarkation facilities for water and aircraft to points such as Avalon on Catalina Island.

The last reach of county shoreline stretches from the north bank of the Los Angeles River to the Orange County Line, a distance of approximately 9 km (5.5 miles). All of this shore is owned by local governments and used for public recreation with the exception of a Navy landing. Sandy beaches exist on 7 km (4.5 miles) of this beach.

Bluff Park lies on the Long Beach waterfront and includes 10 acres of shoreline property. It is administered by the City of Long Beach.

Alamitos Bay has been converted to a large recreation complex containing the Long Beach Marina, residential areas and the Marine Stadium complex. Marine Stadium connects with the inland Recreation Park Complex. Marine Stadium consists of 61 land acres and 82 water acres. Visitation in 1969 was 1,870,200. Recreation Park consists of 245 land acres, including 5 acres of swimming beach, and 16 water acres. Visitation was 1,500,000 in 1969.

All totalled, the Long Beach beachfront area has a total of 229 acres of swimming beach which had a visitation of 16,000,000 in 1969.

Santa Catalina Island lies approximately 29 km (18 miles) southwest of Los Angeles Harbor. The island is mountainous with rocky shores and numerous pocket beaches. It is entirely privately owned and utilized primarily as a ranch. World-famed as a resort, Catalina is the destination of multitudes of boaters and tourists. Primary destinations are the City of Avalon and Isthmus Cove. Many coves with pocket beaches on the north side of the island are maintained by yacht clubs as private anchorages and recreation sites.

Public landings are available by permit at other portions of the shoreline.

Public recreation is available within the City of Avalon at 6 acres of public beach.

In addition to the heavy boating use of its waters, Catalina is a magnet for skin and scuba divers who savor its clean waters and abundant fish. The island's waters are used as a training area for novice divers. Divers from all parts of the country come to Catalina to dive.

San Clemente Island is a U.S. Naval Reservation used for aerial gunnery, bombing and aircraft landing operations. It is about 29 km (18 miles) South of Catalina Island. San Clemente has a spectacular, precipitous eastern shoreline with a gentle western shore. Its 80 km (50 miles) of coast is largely rocky but has a few pocket beaches. It appears to be suffering erosion problems probably caused by the plague of feral goats inhabiting the island. Divers and party boats use the surrounding waters but no public landings are permitted.

While much of the Los Angeles County coastline has been devoted to both public and private recreational purposes, it is still woefully shy of meeting the demand. Future demand is expected to continue increasing. According to the Bureau of Outdoor Recreation, (1973) the total recreation use at California State Parks on the Los Angeles County Coast which were operated by the California Department of Parks and Recreation was 497,083 recreation days in 1969. By 1980, that figure is expected to increase to 665,700 recreation days. While these amounts represent less than one percent of the total

Los Angeles County

TABLE II-58

SMALL CRAFT HARBORS AND LAUNCH FACILITIES

<u>Name and Location</u>	<u>Operating Agency</u>	<u>Type and Estimated Capacity</u>
AVALON HARBOR Santa Catalina Island	City of Avalon	Protected anchorage-mooring for 300 boats inside, 50-60 boats outside.
CATALINA HARBOR Santa Catalina Island	Private	Marina- 150 moorings (est.) Potential berthing for 800 boats
EMERALD BAY Santa Catalina Island	Private	Marina- 10-20 moorings Potential berthing for 400 boats
CAMP FOX	Private	Marina- 25-30 moorings
WHITES LANDING	Private	Marina- 100-150 moorings
CHERRY VALLEY	Private	Marina- 25 (est.)
CABRILLO BEACH	Los Angeles Rec & Parks Dept	Launch facility- 200 boats per day
GOLDEN AVENUE RAMPS Southern terminus of Golden Ave Long Beach	City of Long Beach	Launch facility- 200 boats per day
KING SMALL CRAFT HARBOR Redondo Beach	City of Redondo Beach and Private lessees	Marina-1,538 boats. Launching capability estimated to be 600 boats per day
LONG BEACH HARBOR Long Beach	Long Beach Marine Dept & Private lessees	Marina- berthing for approximately 2380 boats. Launching capability estimated to be 675 boats per day
Long Beach Marina Alamitos Bay Long Beach	Long Beach Marine Dept	Marina- berthing for 1526 boats. Preliminary planning shows ultimate capacity of 2,900 berthing spaces. Launching capability estimated to be 425 boats per day

LOS ANGELES HARBOR San Pedro (L A)	Los Angeles Harbor Dept & private lessees	Marina - berthing for approximately 3,200 boats. Launching capability estimated to be 425 boats per day
MALIBU LAGOON BEACH STATE PARK (Pvt.) Malibu Pt.	County Dept of Small Craft Harbors	Launch facility - potential capability of 550 launchings per day. Proposed facility in regional park.
MARINA DEL REY Marina Del Rey	County Dept of Small Craft Harbors and private lessees	Marina - Currently 6,000 boats. Ultimate launching capability estimated to be 1,490 boats per day.
PARADISE COVE (Pvt) East of Point Dume Malibu area	County Dept of Small Craft Harbors	Marina - potential berthing for approximately 1,535, and mooring for approximately 115 boats. Potential launching capability estimated at 500 boats per day. Existing private facility estimated to be capable of launching 100 boats per day
PORTUGUESE BEND (Pvt) Palos Verdes Peninsula	County Dept of Small Craft Harbors	Marina - potential berthing for approximately 900 boats
SANTA MONICA HARBOR Santa Monica	Santa Monica Harbor Dept	Marina - mooring for approximately 32 boats
SEQUIT POINT (Pvt)	County Dept of Small Craft Harbors	Protected anchorage - potential berthing for 200 boats, mooring for 200 boats, and launching capability for 400 boats per day. Part of Carrillo Beach State Park acreage
TOPANGA CANYON (Pvt) Mouth of Topanga Canyon Malibu area	County Dept of Small Craft Harbors	Launching facility - potential capability of 400 boats per day

This table adapted from: Los Angeles County Regional Recreation Areas Plan, 1965 with updating where data was available.

There are at least seven Party Boat Landings and 17 launching facilities in the county.

recreation use along coastal Los Angeles County, it would probably not be unreasonable to expect a similar proportionate increase countywide.

The State proposes coastline landscape preservation projects at Leo Carrillo State Park, and the proposed Anaheim Bay State Park.

Boating Facilities

Recreational boating comprises a large portion of the County's recreation activity. Boating activities include fishing, sailing, overnight camping, swimming and racing.

The *Los Angeles County Regional Recreation Areas Plan* (1965) studied all existing and potentially developable boating facility sites in Los Angeles County including Santa Catalina Island as based on studies and recommendations of Small Craft Harbors and County Engineers. The total capability as reported in the plan therefore represents the ultimate capability of the Los Angeles County shoreline plus the known capability of existing and future inland bodies of water.

This plan recognized an ultimate capacity for daily launch and recoveries of approximately 6,500 small craft, berthing capability of approximately 20,000 and mooring capability of approximately 600.

Orange County

While growth in Los Angeles County has slowed or perhaps even regressed, Orange County, its neighbor to the south has undergone an explosive expansion of population and associated urbanization. This 782 square mile county is faced with mounting recreation demands and tough land use decisions. The county is blessed with 68 km

(42 miles) of highly esteemed coast, most of which is broad, sandy beach. Orange County's Planning Department notes that the county's 42 mile stretch of beautiful coastline is considered by many to be its most highly treasured natural resource. By the Department's estimate, some 20 million people annually utilize the county's coastline for fishing, surfing, swimming and sunbathing. Besides its beaches, Orange County's physiographic features are made up of the rapidly developing alluvial plain of the Santa Ana River, the Santa Ana Mountains in the east and the coastal hills and bluffs of its southern portions.

Orange County's shoreline ownership and characteristics are shown in the following table.

Orange County Shoreline
Ownership-Use-Sandy Beach

	Ownership		Use				Sandy Beach
	Public	Private	Public Rec	Private Rec.	Non-Rec. Develop.	Un-Develop.	
Orange County	25.8 mi (41 km)	16.2 mi (26 km)	25.5 mi (41 km)	13.6 mi (22 km)	1.8 mi (3 km)	1.1 mi (2 km)	33.4 mi (54 km)

Adapted from: *National Shoreline Study*, USCOE, 1971.

Beginning at the mouth of the San Gabriel River, which marks the Los Angeles-Orange County Line, the coastline stretches 29 km (18 miles) to Newport Beach. All of this reach is sandy beach with interruptions only at the harbor entrances and river mouth jetties. Approximately 87% of this shore is publicly owned, mostly by local entities and used for public recreation. The 13% which is privately owned is used for

recreational purposes. The backshore is developed at Seal Beach through Sunset Beach, where it becomes largely undeveloped in the Bolsa Bay area, extending within the City of Huntington Beach. It is developed in Huntington Beach and Newport Beach with little development in the intervening strip.

State beaches in this segment are Bolsa Chica and Huntington State Beaches. Bolsa Chica is 84 acres in size with 4714 m (15,463 ft) of ocean frontage. Visitor attendance was 1,748,021 in the 1972-73 F.Y. Activities include swimming, fishing, surfing and picnicking. Temporary facilities at the park are being converted to permanent installations.

Huntington State Beach is just downcoast of the City of Huntington Beach. It has 78 acres and 3323 m (10,900 ft) of ocean frontage. Swimming, fishing, surfing and picnicking are current activities at the beach with camping facilities planned for the future.

County facilities operated by the Orange County Harbor District include Sunset Beach, 11th Street Beach, Santa Ana River Beach, Newport Harbor, Newport Dunes Aquatic Park and Upper Newport Bay. Sunset Beach has 23 acres of beach and a 1969 visitation of 773,376. Eleventh Street Beach has 0.2 acre of beach, while the Santa Ana River Beach has 2.9 acres total. Upper Newport Bay is primarily a boating installation with land support suitable for picnicking. Newport Harbor is an extensive boating installation with 120 acres of swimming beach included in the complex. Attendance in 1969 was nearly 2 million people. Newport Dunes Aquatic Park is also within Newport Bay and provides 20 acres of swimming beach

with an annual attendance for 1969 of 259,328.

Local facilities include Seal Beach, Huntington Beach, Newport Beach, and Corona del Mar State Beach.

Seal City Beach is 100 acres in size and received 3,300,000 visitor-days of use in 1971. Huntington City Beach has 37.5 sand acres and received a visitation of 6,278,000 in 1971. Newport City Beach is 224 sand acres in size and received 8,200,000 visitor-days of use in 1971. Corona del Mar State Beach is operated by the City of Newport Beach, contains 30 acres and 744 m (2439 ft) of ocean frontage. It supplied 500,000 visitor-days of use in 1971.

The next segment extends from Corona del Mar to Dana Point, a distance of 24 km (14.6 miles). This shoreline is rocky, accented by numerous points and freestanding offshore rocks and punctuated with numerous small pocket beaches. The backshore consists of bluffs ranging in height from 9 to 40 m (30-130 ft). The shoreline is developed at Corona del Mar but undeveloped south to Laguna Beach except for the small settlement at Crystal Cove. Development extends from Laguna Beach through South Laguna where it is undeveloped southerly to Dana Point. Seventy-two percent of this coastal reach is privately owned and 15 km (9 miles) of the 17 km (10.5 miles) is used for private recreational purposes with the remaining 2 km (1.5 mile) available to the public.

There are no State Park units within this segment. County facilities include Sunset Aquatic Park, Aliso Creek, South Laguna, 3 Arch Bay and Niguel Beaches. Sunset Aquatic Park has picnic and marina facilities. Aliso Creek Beach is just north of South Laguna

and includes 18 acres of beach with 5 acres of parking. Visitation in 1969 was 136,896. South Laguna Beaches have 6 acres of beach and include the Heisler Park Marine Life Refuge and South Laguna Beach Marine Life Refuge. Three Arch Bay has 0.3 acre of beach. Niguel Beach, with 31 acres, completes this segment to Dana Point.

The final county segment extends 15 km (9.3 miles) from Dana Point to the San Diego County Line at San Mateo Point. This area comprises the landward side of the Capistrano Bight. The shoreline consists of sandy beaches backed by 30 m (100 ft) bluffs. Development occurs on approximately 50% of the backshore. Sixty-three percent of the shore is publicly owned and nearly all of this is available for public recreation. Two-thirds of the private shoreline is devoted to recreational use.

State recreation units in this segment include Doheny and San Clemente State Beaches. Doheny State Beach is located on the City of Capistrano Beach waterfront. It consists of two separate areas aggregating 62 acres. Day use facilities are in the north section with camping facilities in the southerly portion. A total ocean frontage of 2002 m (6567 ft) is available. Day use facilities include picnic set-ups for both large and small groups. Activities include fishing, swimming and surfing. There are 115 camping units installed with plans to expand these to accommodate more of the reported 50,000 turnaways from the campground. Citizen group objections have recently arisen to plans for overnight facility expansion, claiming that the need for day use is much greater. Total visitation was 536,435 for the 1972-73 F.Y.

San Clemente State Beach is located at the City of San Clemente and is 110 acres in size. It has 157 camping units with facilities for trailer camping (72 units) and general camping. Group camping facilities are also provided. Day use facilities include 26 picnic units and group capabilities for 150 people. Activities include swimming, fishing, surfing, and diving for abalone and spiny lobster. The 1829 m (600 ft) of ocean frontage attracted a total of 329,625 visitors during F.Y. 1972-73.

Local facilities include beaches at Dana Cove and the San Clemente City beach. Dana Cove is operated by the county and provides 1 acre of swimming beach which served 100,000 visitors in 1969. San Clemente City Beach and Pier offers 23 acres of sand which attracted 1,466,108 visitor-days of recreation use in 1971.

Boating Facilities

Like Los Angeles County, Orange County has a large contingent of boaters. Marina facilities are shown in the following table:

<u>Name</u>	<u>Number of Boats</u>
Huntington Harbor	2500
Sunset Aquatic Park	575
Newport Bay (Lower & Upper)	8632
Dana Point	1400

Including the above, there are at least ten launching facilities and six party boat landings. The most common destinations of Orange County boaters are the nearshore waters and Catalina Island.

San Diego County

San Diego County embraces 4,255 square miles situated at the southwesterly corner of the continental United States. The county contains three sharply contrasting geographic sub-regions of roughly equal size: the coastal strand and foothills, the central mountains, and the eastern desert. Most of the population is concentrated in the western third of the county where moderate climate, ocean and bay frontage, and developable terrain have invited human settlement. Flat mesas interspersed with canyons and river valleys gradually give way to rolling foothills as one proceeds east from the coast. The central mountains extend almost to the Mexican border. Lower slopes are covered with chaparral, but there are substantial timber stands at higher elevations. Watersheds, wildlife habitats, range lands, and recreation are the principal uses of the mountain area. The arid desert sub-region possesses a unique natural beauty, but its fragile soils and vegetation do not lend themselves to intensive utilization.

Over half the land in the county (2,685 square miles) is in public ownership, but much of this is in military reservations or in mountain and desert areas far from urban centers. Much of the federal land is U.S. Naval property. Other major federal lands include Cleveland National Forest (430 square miles) and Bureau of Land Management holdings (291 square miles), mainly in the central mountains. Indian reservations and other lands administered by the Bureau of Indian Affairs account for 193 square miles.

Over the past three decades the county's population has grown by over 400 percent - a rate considerably faster than the growth of the State as a whole. In 1940 the population was less than 300,000, but it almost doubled in the next decade, primarily because of the impact of World War II. This high growth rate continued in the post-war period, with the county's population exceeding 1 million in 1960. Consistent with state-wide trends, the rate declined in the last half of the 1960-70 decade. The latest census counted 1.36 million persons.

The results of adding almost three quarters of a million people to the county's population in 20 years have drastically changed the character of the coastal sub-region. Once relatively small, self-contained communities have become engulfed in urban sprawl and have nearly lost their identity. The City of San Diego and its neighbors (La Mesa, El Cajon, National City, Chula Vista, and Imperial Beach) have grown together to form an almost unbroken urban mass. Hillsides have been cut down, canyons have been filled, and other natural features have been destroyed to make way for development. In many areas open space has become a scarce commodity.

Because open space and climate are the most important elements of the San Diego life style, it can fairly be said that as the county has grown, the quality of life has diminished. Although an enormous amount of open space remains available for public use in the mountain and desert sub-regions, there is a pressing shortage of recreation areas within and in close proximity to urban centers. Currently San Diegans are beginning to take stock of the results of three decades of relatively uncontrolled growth. Based on apparent environmental and

financial consequences, some are questioning the advantages of rapid urbanization. Comparisons are being made with the Los Angeles-Orange County metropolitan monster that lies to the north. Few believe that the San Diego area should emulate its neighbors. There is general agreement that the most precious assets that would be lost are clean air, open space, freedom from congestion and access to open space.

Paradoxically, the root cause of most of San Diego's growth in the past decade was environmental amenity. Particularly in the late 1960's when the pace of state-wide growth had significantly declined many businesses selected San Diego County as the prime remaining unspoiled Southern California coastal location. The population growth these new industries and offices generated required new homes, stores, schools, and service facilities. Pro-growth public policy generally imposed minimum constraints on the location of new development. As a consequence the coastal sub-region lost much of its precious open space-open space that was a prime element of its scenic setting and recreational resources.

Provision of access by the Coast Highway (now Interstate Route 5), without reservation of significant amounts of open space for public use, determined that the coastal strand will be predominantly urban, even where natural conditions dictate otherwise. Construction of Interstate 8 Freeway spurred development of the La Mesa-El Cajon area; and improvement of Route 395 (now Interstate 15) eased commuting from Poway, Rancho Bernardo, and Escondido to Central San Diego, as well as

generating current pressure for development of North City. As these and other public projects have made ever greater amounts of land potentially subject to urbanization, increasingly important open spaces have been lost.

In the light of the fact that much of the needless loss of open space in San Diego County occurred after the grim consequences of Los Angeles and Orange Counties' growth signalled warnings in the 1950's and early '60's, it would appear that there is only limited cause for optimism regarding future prospects. However, in recent years the public has become increasingly aware of the need to check the more devastating aspects of uncontrolled urbanization. Concern has arisen not only over environmental consequences, but also over the costs of new development to the taxpayers at large. Recent events demonstrate that public officials are reacting to anti-development pressures and heeding warnings of their staff members that formerly were frequently ignored. These portents suggest that growth at-any-cost policies are being abandoned by local governments (San Diego County, CPO, 1972).

Of the County's 122 km (76 miles) shoreline, 73% is publicly owned. Forty-four percent of the coast is available for public recreation use. Most of the beach is sandy except in the Pt. Loma Peninsula area where some rocky points and cobble beaches occur.

The first shoreline segment extends 28 km (17.7 miles) from San Mateo Point to the San Luis Rey River north of Oceanside. This entire reach is within the Camp Pendleton Marine Base. The northern 5 km (3 miles) or so is moderately wide sandy beaches which turn into narrow beaches backed by cliffs varying from 18 m to 46 m (60-150 ft) in

height through the central sector. The southerly 5 km (3 miles) are wide beaches backed by the Santa Margarita Lagoon. There is little development in this reach with the exception of San Onofre State Beach and the San Onofre Nuclear Generating Plant in the northerly portion. There are some Marine Corps installations at the southerly end. Limited surf fishing is allowed by permit when landing maneuvers have not been scheduled.

San Onofre State Beach is located on 2945 acres of land under a 50 year lease to the State from the Department of Defense. This beach is undeveloped and the intention is to keep it that way. Activities on the 7585 m (24,880 ft) of ocean front include swimming, fishing, surfing and sunning. Camping is permitted on an abandoned stretch of highway on the bluffs. About 250 campers or trailers can be accommodated. Tent camping is impractical because of the asphalt, however, a few primitive tent campsites are available on a terrace immediately adjacent to the beach. Visitation was 212,650 in 1972-73 F.Y. There are no other public recreation sites within this reach.

The next segment extends from the San Luis Rey River to the Soledad River south of Del Mar, a distance of 34 km (21.3 miles). Beaches are generally wide and sandy backed in scattered portions by low cliffs and marine terraces. Local governments own 65% of the shore, nearly all of which is available for public recreational purposes. The majority of the backshore is developed and largely urban in character.

There are six State Beaches in this shoreline segment.

Table II-59 gives information pertaining to resources, facilities

and visitation.

TABLE II-59

California State Beaches in the Segment				
State Beaches	Size (acres)	Camping Units	Ocean Frontage (Meters-Feet)	Visitation (FY 1972-73)
Carlsbad	14		1655 - 5429	310,303
South Carlsbad	45	226	3668 - 12032	311,804
Leucadia	11		1640 - 5380	150,111
Moonlight	14		555 - 1820	234,247
San Elijo	39	171	2784 - 9130	363,972
Cardiff	11		1164 3819	97,215

Activities at these beaches include surfing, swimming, diving (skin and scuba), sunbathing, fishing, sightseeing, camping and picnicking. Camping is limited to a seven day stay because of the beaches' popularity.

County Parks and Beaches include those in Table II-60.

Table II-60
San Diego County Parks in Segment

<u>Park</u>	<u>Size</u>	<u>Visitation</u>
Encinitas	2 acres	N/A
Seaside Gardens	9 acres	N/A
Sea Cliff	0.4 acre	72,000 (1968)
Tide Beach	1 acre	58,000 (1968)
Leucadia Roadside	N/A	N/A
County Park		200,000 (1968)
Solano Beach Park	8 acres	

The next segment begins at Torrey Pines State Park and extends south 22 km (13.7 miles) to the entrance of Mission Bay Park. Fifty-seven percent of this reach is publicly owned and all is available for public recreation. The privately owned land is considered to be in recreational use. The northern portion is in a State recreation area and is very lightly developed but the southern portion is highly urbanized through the communities of La Jolla and Pacific Beach. Most

of the shore is sandy beach with approximately 5 km (3 miles) of rocky areas along the La Jolla Peninsula.

Torrey Pines State Reserve and Beach are the only units of the State Park System in this reach. These contiguous areas total nearly 900 acres with 60 acres and 7200 m (23,613 ft) of ocean frontage. This park was established to preserve one of the world's rarest trees, the pines that give the park its name. An ice age relic, the tree is known only at the Reserve and on Santa Rosa Island. At the north end of the Reserve, the Los Penasquitos Lagoon has been designated as a Natural Preserve because it is in a nearly natural condition.

Attendance at the Reserve is limited to 500 people at one time to protect the delicate ecosystems.

Beach recreation consists of swimming and surfing.

Table II-61 lists San Diego City Parks, the majority of which fall within this segment.

Table II-61
City of San Diego Parks

<u>Park</u>	<u>Acreage</u>
Scripps Park	5.60
La Jolla Cove	1.00
La Jolla Shores	6.00
Neptune Park-Wind n' Sea	2.77
Coast Blvd. Park	4.55
Nicholson's Pt. Park	1.04
La Jolla Strand	0.90
Hermosa Terrace Park	0.92
La Jolla Hermosa Park	0.30
Palisades Park	3.31
North & South Pacific Beach	3.14
Mission Beach	83.45
Tourmaline Surfing Park	N/A
Children's Pool	-
Kellogg Park	N/A
Palisades Park South	N/A
Ocean Beach Park	30.98
Sunset Cliffs Beach	17.22
Santa Clara Point	N/A

Mission Bay Park, a recreational development of some 4300 acres, lies inside the strand at Mission Beach. This facility has marinas, parks and beaches, golf courses and commercial facilities. It is heavily utilized by boaters. A wildlife sanctuary occupies the eastern portion.

The next segment begins at Mission Bay's entrance and extends south the length of Point Loma to the San Diego Bay entrance. This 14 km (9 miles) stretch is mostly rocky except for approximately 0.8 km (0.5 miles) of sandy beach (Ocean Beach Park) just south of the mouth of the San Diego River. The beach is about 122 m (400 ft) wide near the river, narrowing to cliffs to the south. A municipal pier extends from the southern end of the beach area. The remaining portion of the shoreline is wave-cut benches, pocket beaches and sea caves. The backshore is urbanized in the northern portion, south to Sunset Cliffs. The remainder is in the Fort Rosecrans Military Reservation and is largely undeveloped. Cabrillo National Monument occupies a position near the southern end of Point Loma. Public recreation is available only at Ocean Beach Park.

San Diego Bay is a large complex containing numerous Naval facilities, commercial docks and recreational boating installations.

The final segment extends 23 km (14.3 miles) from the San Diego Bay entrance to the Mexican border. Nearly all of this is sandy beach but much of it is owned or leased by the Department of Defense. Public recreation is available at Silver Strand State Beach and at Borderfield. The City of Coronado occupies the peninsula and provides recreation at Glorietta Bay and Central Beach.

Silver Strand State Beach has 427.72 acres with 7165 m (23,500 ft) of ocean frontage. There are picnic facilities for 129 family units. Visitation for the 1972-73 F.Y. was 275,538.

Borderfield State Beach lies immediately north of the National Border and has 374 acres of state-owned land and 283 acres of leased land. There is 1841 m (6040 ft.) of ocean frontage. Visitor attendance was 114,422 for the 1972-73 F.Y.

Shoreline recreation areas in San Diego County seem to have a bright future. State Park attendance, which amounted to 2,054,907 recreation days in 1969, is expected to climb to 2,830,600 recreation days by 1980. Also by 1980, San Onofre State Beach will add 250 camp units and Silver Strand State Beach will add 315 camp units. Proposed landscape preservation projects include Torrey Pines State Park, a 9,605 acre expansion of Torrey Pines State Reserve, and Tijuana River State Park which would total 7,455 acres.

The County of San Diego has developed plans to implement a system that will eventually total 39 regional parks. Of that total, seven are on the coast and are either existing or are among the highest priority for development. The following are among those regional parks not previously listed:

<u>Name of Parks</u>	<u>Total Acreage - 1990</u>
Buena Vista Lagoon	222
Aqua Hedionda	1,407
Batiquitos Lagoon	1,416
San Elijo Lagoon	614

The regional park system of San Diego County will provide a variety of recreation experiences along the coast from high density

intensive use at beach areas to quiet observation in ecological preserves.

Attendance at City of San Diego beach areas also promises to increase substantially in the future. By 1980, the attendance is expected to reach 7,100,000 as compared with the 1968 (FY) attendance of 5,577,008.

The City of Oceanside is currently developing a major addition to its facilities in the form of La Salinas Park, which will be three blocks long, 400 feet deep and will offer a variety of activities.

Boating Facilities

Boating activities are very prominent in San Diego County as they are in its two northern neighbors. Harbors include Oceanside Small Craft Harbor, Mission Bay and San Diego Bay.

Oceanside Small Craft Harbor has 760 boats berthed. Mission Bay Park has 2400 boats, Coronado Yacht Club (Glorietta Bay), 82 slips and 108 boats, Del Coronado Boathouse, 36 slips and Shelter Island (Yacht Harbor and Commercial Basin) 2300. The total for San Diego Bay is approximately 3530 boats.

Much of the boating takes place within the large bays of Mission Bay and San Diego Bay. Destinations outside of the harbors include the Baja California Peninsula, Orange County harbors and Catalina Island.

The preceding county by county compilation lists the majority of the recreation sites along the immediate coast and others which are close enough to be a part of the coastal environment. Undoubtedly numerous other sites exist at varying distances inland which occupy vantage points commanding ocean vistas. The ocean is thus a part of

the environment of these areas as well. Recreation sites are depicted in Graphic No. 4. Reference to this visual aid will amply demonstrate the dominance of recreation use of the Southern California Coastline. Proposed recreational developments are likewise depicted on Graphic No. 4.

In addition to the public facilities shown on Graphic No. 4, many of the intervening private lands can be considered recreational in nature. Some are open to the public while others are utilized by their owners for active recreation such as swimming, surfing and so on. Passive recreation plays an important part in the use of private residential shoreline. Peaceful enjoyment of the ocean scene and environment plays an important part, for many people, in the "re-creation" so important to every individual.

Use figures have been included where available, and while they are by no means all inclusive, they do serve to indicate the magnitude of visitation to coastal parks. These figures do not indicate latent demand, that demand which is unindicated and unsatisfied because of crowding. This demand is evident in turn-away figures plus unknown numbers of people who have failed to present themselves at the entrance gate, knowing in advance that the facilities were likely to be at capacity already.

Tables II-62 and II-63 analyze the geographic breakdown for the total California coastal area.

TABLE II-62

1969 RECREATION USE IN VISITOR DAYS
California Coastal Strip Landscape Province

	Oregon to Golden Gate	Golden Gate to Pt. Conception	Pt. Conception to Mexico	Total Coastline
State Parks	3,500,081	12,033,602	7,400,479	22,934,162
Other Public	1,355,374	11,390,158	85,540,729	98,286,261
Private	175,560	226,255	403,264	805,079
Total	5,031,015	23,650,015	93,344,472	122,025,052

PERCENT OF AGENCY USE BY
GEOGRAPHICAL AREA

	All Agencies	Read Down State Parks	Other Public	Private
Oregon to Gold. Gate	4	16	1	22
Gold. Gate to Pt. Concept.	20	52	12	28
Pt. Concept. to Mexico	76	31	87	50
Total	100	100	100	100

PERCENT OF GEOGRAPHICAL AREA USE
BY AGENCY

	Total Coastline	Read Down Oregon to Golden Gate	Golden Gate Pt. Conception	Pt. Concept. to Mexico
State Parks	19	70	51	8
Other Public	81	27	48	92
Private	1	3	1	1
Total	100	100	100	100

Source: Hanshew, Ron, Calif. Coastline Rec. Tip No. 2, Sept. 1970,
State of Calif. Dept. of Parks and Recreation, May 1974.

TABLE II-63
1969 RECREATION USE IN VISITOR DAYS
California Coastal Strip Landscape Province
By County

COUNTY	OPERATING AGENCY					
	Federal	State	County	Local	Private	Total
Del Norte		142,065		135,000	1,460	278,525
Humboldt	6,575	395,002	61,700		2,725	456,002
Mendocino		546,645		50,000	95,985	692,630
Sonoma		1,117,330	70,330		13,230	1,200,890
Marin	797,729	1,409,079	134,000		62,160	2,402,968
San Francisco		205,360		6,130,720		6,336,080
San Mateo		3,618,137	1,602,496	667,704	400	5,888,737
Santa Cruz		2,761,011		- 100,000	18,000	2,879,011
Monterey	250,000	461,489		60,000	13,000	784,489
San Luis Obispo		4,526,534	1,640,778	233,472	164,855	6,565,639
Santa Barbara	58,000	461,071	546,988	100,000	30,000	1,196,059
Ventura	17,105	1,859,215	685,850	624,992	1,600	3,188,762
Los Angeles		497,083	21,800,318	45,734,989	274	68,032,664
Orange		3,486,357		11,151,824		14,638,181
San Diego	1,034,000	2,054,907		3,994,568	401,390	7,484,865
TOTAL	2,163,409	23,541,285	26,532,460	68,983,269	805,079	122,025,502

Source: Hanshew, Ron, Calif. Coastline Rec. Tip No. 2., Sept. 1970, State of Calif. Dept. of Parks and Recreation, May 1974.

Recreational boating has been growing by leaps and bounds ever since 1886, when the San Diego Yacht Club was established. In 1973 there were over 179,000 boats in Southern California. More than one in four recreational boats in California were owned by Los Angeles County residents. Although large increases in boat registrations occurred through the 1960's, the future picture is not clear. The passage of Proposition 20, the California Coastal Zone Conservation Act of 1972, combined with increasing concern for maintaining the integrity of the few remaining coastal wetlands, makes it unlikely that any large scale expansion of marina facilities will occur. Thus, without major expansion at existing marinas, boat storage will have to be increased by means of dry type storage. Developments of this type may not fare well within Proposition 20 controls either. It would appear that boating growth will be leveling off, at least for the near term.

b. Esthetic Resources

Esthetics has its origin in that store-house of sensory perceptions which continually assail the human body, to be assimilated by the brain and molded by the individual's philosophical standards, to form a perception of beauty. Since the conception of what is esthetic or beautiful is wreathed in human creativity and emotion, a plethora of divergent views will emerge from any discussion. Certain principles, however, do emerge which are susceptible to analytical treatment. These are primarily concerned with visual perceptions, as other types of stimuli such as sound and smell are fairly easily categorized as pleasant, neutral, or unpleasant. Touch may be readily

characterized in many ways such as cold, warm, slimy, wet, rough, prickly and so on.

Visual perceptions are measured in terms of color, which consists of hue, chroma, and brightness; texture, form, arrangement and other factors which combine to form the perceived image.

The image perceived may have a sense of unity and harmony, the values which arouse our sense of "beauty." Views of the natural environment usually exhibit unity and harmony. Well designed and sited buildings that relate to one another exhibit these qualities. Ugliness results from a sensed lack of unity among elements or the presence of incongruous elements. Such discord can result even from a combination of beautiful entities in an unlikely juxtaposition, such as the finding of a well manicured lawn and hedges in the back country of Yosemite Park.

Whether consciously or subconsciously perceived, the concept of beauty affects the mental equilibrium and well-being of everyone. Variety and harmony are some of its important components and can enhance one's experience on a crowded street as well as in the solitude of wilderness.

"Man is beginning to realize that the environment he has created is often esthetically ugly, monotonous and polluted--reflecting a breakdown in the natural order as well as hazards to human health. More than ever before, a man feels a need to make contact and associate with his natural environment. Appreciation of esthetics varies with each individual's background, and the planning process is further complicated by our inability to measure such intangibles in economic terms." (Cal. Region Comp-Framework Study, Appx. XII 1971)

Components of the visual resources are: flora, fauna, water, land, air and artificial objects. Perceptions occur on both a macro and micro scale. The esthetic microcosm of a beach, for example, consists of multicolored and sized sand grains, cast up shells, traces in the sand left by wind moved grasses, shore birds and other features which comprise the coastal environment. Sand dunes, cliffs, bay vistas and mountains make up the macro-view of our coast.

Each landscape has its own character which renders it distinct. Consider the difference in appearance and evoked mood between a dense Douglas-fir forest and a Death Valley vista; between a Georgia swamp and an alpine meadow, or the sea coast and a Kansas grassland. Landscape characters are discernible and diverse even within a similar feature such as the California shoreline. Shorelines consist of broad, sandy beaches, rocky promontories, bluffs, offshore rocks, lagoons and harbors, each differing from the other. Changes in light, clouds, sea conditions and wind all evoke different responses in the viewer even though he occupies the same beach vantage point. Changes in perception occur according to what we expect to see versus what we actually see.

It can be seen from the preceding discussion that esthetic values are very qualitative in nature and thus subject to any number of varying interpretations. We feel that these values are perhaps the overriding factor in a human's conception of his total environment and thus must be carefully considered.

The general character and appearance of the Southern California coastline has been described in the preceding recreation discussion and will not be reiterated here. A brief recap of the general values will be beneficial, however.

Southern California's coastal esthetic situation ranges from relatively pristine beaches and shores to the dredged, filled, developed, and beach house draped shores of many estuaries and beaches.

Offshore views are usually unobstructed save for passing ships and boats. Offshore loading facilities are located near San Diego at Encina, near Los Angeles at El Segundo and near Oxnard at the Edison Plant. Offshore drilling platforms are located in a portion of Santa Barbara Channel. Artificial islands have been built in the Los Angeles-Long Beach Harbor area and the drilling rigs located thereon disguised to look like tall buildings. Palms and other landscaping help to disguise the clutter of oil equipment. In Southern California, the nearer offshore islands may frequently be seen from shore.

Visibility increases from north to south due to the greater frequency and duration of fog along the north coast. Annual visibility ranges for Santa Monica Bay, for example, show visibilities of less than 5 nautical miles only 22% of the time. The following table shows visibility averages for selected Southern California points.

Visibility Ranges - Nautical Miles

	January		July	
	<u>5 to 10</u>	<u>10+</u>	<u>5 to 10</u>	<u>10+</u>
Santa Monica	30%	58%	50%	37%
San Pedro	49%	22%	45%	31%
Catalina Island	34%	57%	49%	41%

Discordant features are much more prevalent in highly industrialized areas such as the Los Angeles-Long Beach Harbor complex. Changes in areas such as this will result in far less visual impact than changes in a pristine area.

c. Historic and Archeological Values

California is steeped in history being the place of discovery and early settlement on the west coast. Its history and prehistory on the south coast are those of at least three cultures; the Indian, Spanish and American.

Juan Rodriquez Cabrillo entered San Diego Bay on September 28, 1542 and became the first white man to do so. Continuing northward, he discovered the various Channel Islands and regions in the Santa Barbara Channel. Cabrillo died on January 3, 1543 on San Miguel Island.

Further Spanish incursions resulted in a series of missions being established between San Diego and areas to the north of Point Conception. These enclaves engaged in trade and "civilizing" the Indians. Many of the missions grew into pueblos or towns, many of which constitute present day Southern California towns.

California has done an excellent job of preserving examples of its early history. Many of the original or reconstructed missions still remain. Core areas or "Old Towns" are preserved and open for public enjoyment in Santa Barbara, Los Angeles, and San Diego. Numerous churches, early wells, military installations and early pioneer homes have been designated as California Historical Landmarks and/or listed on the National Register of Historic Places. Most sites that are designated are inland. The following list includes those sites designated as

California Historical Landmarks which are proximal to the coast (a few miles inland) or on it in some instances.

Santa Barbara County

Gaviota Pass	Carpinteria and Indian Village
Burton Mound (Archeological)	of Mishopshnow
Casa de la Guerra	Hastings Adobe
Covarrubias Adobe	Royal Spanish Presidio
Mission Santa Barbara	Carrillo Adobe
Old Lobero Theater	El Camino Real (road)

Ventura County

Site - Father Junipero
Serra's Cross
Old Mission Reservoir
Olivas Adobe
Mission San Buenaventura
Ventura County Courthouse

Los Angeles County

Casa de Governor Pio Pico	Lummis Home
Banning Park	Original Building of the Univ. of Southern California
Dominguez Ranch House	Well, "Alamitos 1"
Drum Barracks	"Heritage House"
Hancock - La Brea	Portola Trail Campsite No. 2
Centinela Springs	Site of the Original U.S. Air Meet
Old Salt Lake	El Camino Real (road)
Homesite of Diego Sepulveda	Old Santa Monica Forestry Station
Whaling Station	
Homesite of Jose Dolores Sepulveda	
Timm's Point and Landing	
Serra Springs	

Orange County

Dana Point	Flores Peak
Old Landing	Diego Sepulveda Adobe
Mission San Juan	Site of the first water to water flight - Newport Harbor
Capistrano	El Camino Real (road)
Barton Mound	McFadden Wharf
Anaheim Landing	

San Diego County

Adobe Church of the Immaculate Conception	The Whaley House
San Diego Whaling Station	Congress Hall Site
Old Pt. Loma Lighthouse	Serra Palm Site
Mission Dam and Flume	Old Spanish Cemetery
Casa de Estudillo	Fort Guijarros Site
Fort Stockton	Casa de Pedrorena
Fort Rosecrans National Cemetery	Casa de Machado
Tip of Ballast Point	Casa de Bandini
La Punta de los Muertos	Casa de Stewart
San Diego Presidio Site	Casa de Carrillo
Casa de Lopez	Casa de Cota Site
Quarantine Station	Mission San Luis Rey
Fort Rosecrans	Mission San Diego de Alcala
Plaza, San Diego Viejo	Derby Dike
"Old Landing," Site of El Desembarcadero	Exchange Hotel
La Cristianita	San Diego Barracks
Montgomery Memorial	Bancroft Ranch House
First Military Flying School	Las Flores Asistencia
San Diego State College, Site of first doctorate degree granted by the California State College System	Kate O. Session's Nursery Site
	Hotel Del Coronado

Archeological values are widespread within the Southern California region. Ancient peoples apparently found this area as much to their liking as does the current population. Prehistoric population concentrated along the coastal strip where they found the climate amenable and the ocean's food resources readily obtainable. The Santa Barbara and Channel Islands areas were inhabited by the historic Chumash and their prehistoric antecedents the Canalino, as archeologists have called them. The Los Angeles - Orange County areas were occupied by the Gabrielino and similar peoples. The Chumash were skilled tool and basket makers, fishermen and hunters. Their most notable accomplish-

ment seems to have been the plank canoe. The craftsmanship and utility exhibited by these canoes was a source of marvel to the Spanish. These canoes enabled the Indians to fish very effectively and thus expand both their range and population.

Archeological sites are found in a nearly continuous strip from the Santa Barbara County shoreline southerly through San Diego County. The concentration is highest in the northerly sector where past conditions were similar to today's with greater abundance of moisture to the north. Flatter lands where streams enter the ocean were often the site of ancient villages.

The Channel Islands were heavily populated in times past and a thriving commerce existed between islands and with the mainland. Although some excavations and reconnaissance projects have been accomplished on the islands, there is no thorough understanding of native use of any of the Channel Islands and most data are inadequate.

The vast majority of sites is younger than 5000 years BP, but sites do range back to generally accepted ages of 10,000-12,000 years BP. Evidence of man has been found on Santa Rosa Island by Dr. Phillip Orr in the form of a cut and burnt mastodon leg which dates to 29,500 BP. Recent dating of material found in San Diego County at San Dieguito indicates man may have been present there more than 40,000 years BP. This would make the area one of North America's oldest inhabited regions and thus, one of the Nation's most valuable archeological resources.

Eustatic sea level changes over the past 40,000 years BP have

caused both the Southern California mainland and the Channel Islands to vary greatly in size. Sea levels reached lows of 144 m (472 ft) below present mean sea level, 40,000 years BP and 124 m (407 ft) below present MSL, 18,600 years BP. At the lower sea stands, the early peoples undoubtedly occupied large areas of land which are presently submerged. Artifacts and middens have been found on the continental shelves. Divers have recovered bowls off the Palos Verdes peninsula and Santa Rosa Island. Other archeologic evidence has been recovered from waters around the other islands. It seems certain that potentially valuable archeological evidence remains on the sea floor where it is less than 144 m (472 ft) deep. Recoverable material is probably restricted to waters less than 46 m (150 ft) deep by limitations in diving technology and of archeologists trained to use it.

In addition to submerged archeologic sites, the sea bottom holds numerous shipwrecks, some of which have historic and prehistoric interest and others may possess significance not yet evaluated. A recent discovery of a Spanish Galleon at an undisclosed location off Southern California, is being salvaged. Speculation exists that several others which are known to have been lost may be found. The National Register of Historic Places lists no places on the islands and there are no places in the nomination process. Existing data regarding the historical and archeological significance of known locations is sparse and until further study is accomplished, information is inadequate for nomination.

d. Sport Fisheries

With only minor changes the following comes from Horn (1974b).

Historical Aspects

Young (1969) reviewed the history of the partyboat fishery in California, and his paper forms the basis of this account. (A partyboat is a boat operated by a licensed skipper and crew and on which fishing space and privileges are provided for a fee). In 1898 the Tuna Angling Club of Santa Catalina Island was formed mainly to discourage the practice of handlining the game fish which then abounded in Southern California waters. Two-man launches, from which rod and reel fishing was conducted, came into being, marking the beginning of the large partyboat fleet that exists today. Tuna Club anglers concentrated their efforts on bluefin and yellowfin tuna, giant sea bass, marlin, swordfish, yellowtail, and white seabass. Barracuda, kelp and sand bass, California halibut, white croaker and Pacific mackerel were utilized most heavily by Southern California partyboat and barge fishermen during the 1920's and later. Central and northern California anglers mainly caught salmon, rockfish, and flatfish.

In 1935, the California Legislature enacted a bill requiring written catch logs from all partyboat operators. The log program was interrupted during World War II but was fully reinstituted by 1947. During the 21 year period, 1947-1967, 400 to 600 boats par-

ticipated in the fishery and a total catch in excess of 71 million fish was reported. Consecutive catch records were maintained of 28 species and species groups. Annual catch totals ranged from 2.0 to 5.4 million fish. In 1947, an estimated 435,000 anglers fished from partyboats, and in 1966, an estimated 857,000. Following a brief downward trend from 1947 to 1952, the sport fish catch from partyboats has risen rather sharply through the period 1953 to 1970 (Figure II-89) , even though catches of individual species fluctuated greatly. Based on Young's (1964) data, the top four species or species groups in terms of numbers caught in the period 1947-1967 were: 1) rockfish, 22,000,000+; 2) kelp and sand bass, 16,000,000+; 3) barracuda, 9,000,000+; and 4) bonito, 8,000,000+.

The partyboat fleet has experienced a downward trend in the number of registered vessels during the period 1953-1967, but the average carrying capacity of the boats has become greater and a larger number of anglers fish from partyboats (Figure II-90). According to Frey (1971) the California partyboat fleet is considered to be in a "healthy condition.

Current Status and Recent Trends

Pinkas, Oliphant, and Haugen (1968) have divided marine sportfishing into four major types: 1) partyboats, 2) private boats, 3) shoreline, and 4) piers and jetties. Their survey of Southern California sportfishing and the review of the partyboat fishery by Young (1969) form the basis for this section.

The Southern California partyboat fishery is distinct. About 75% of the statewide partyboat effort is expended in Southern Calif-

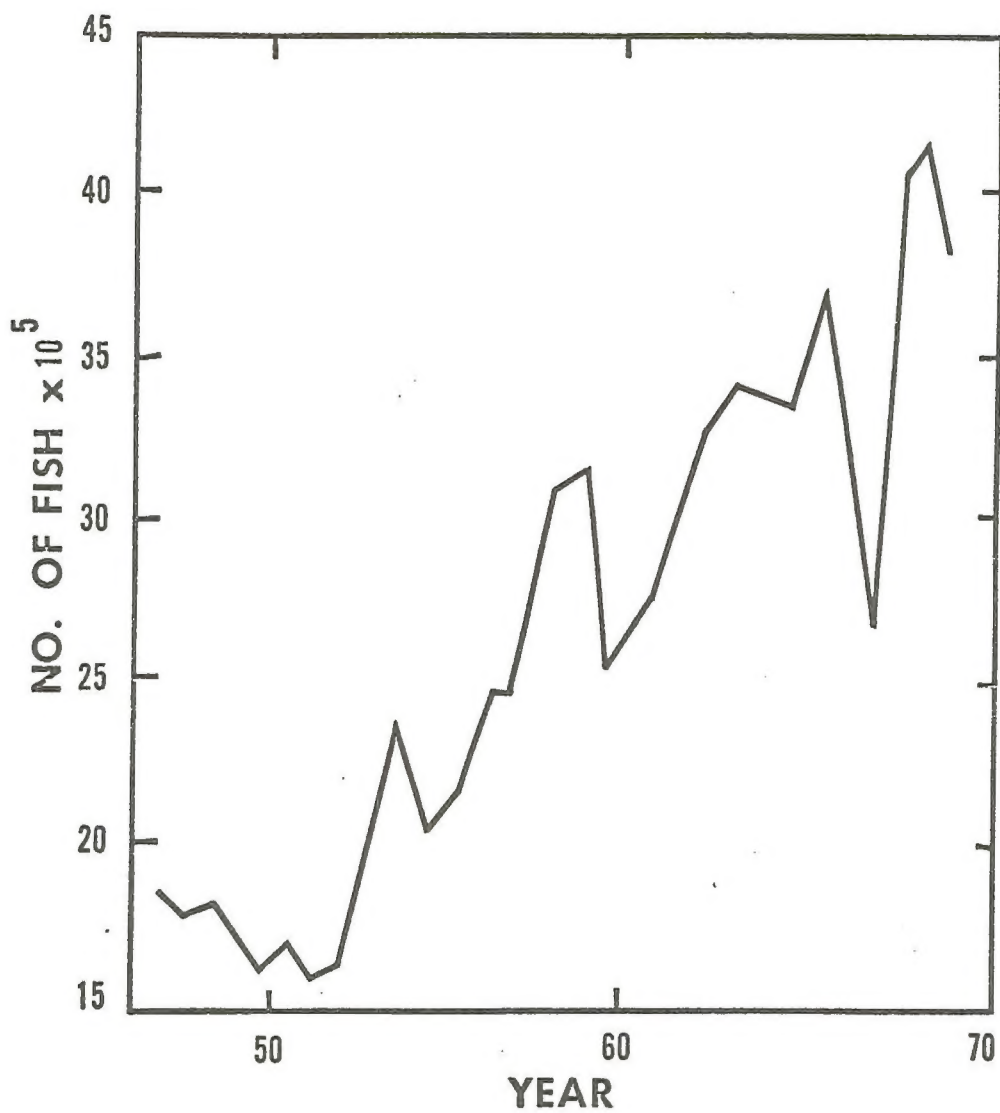


Figure II-89 Total number of fish caught by party boats in southern California waters, 1947-1970. (from SCCWRP, 1973; after Young, 1969).

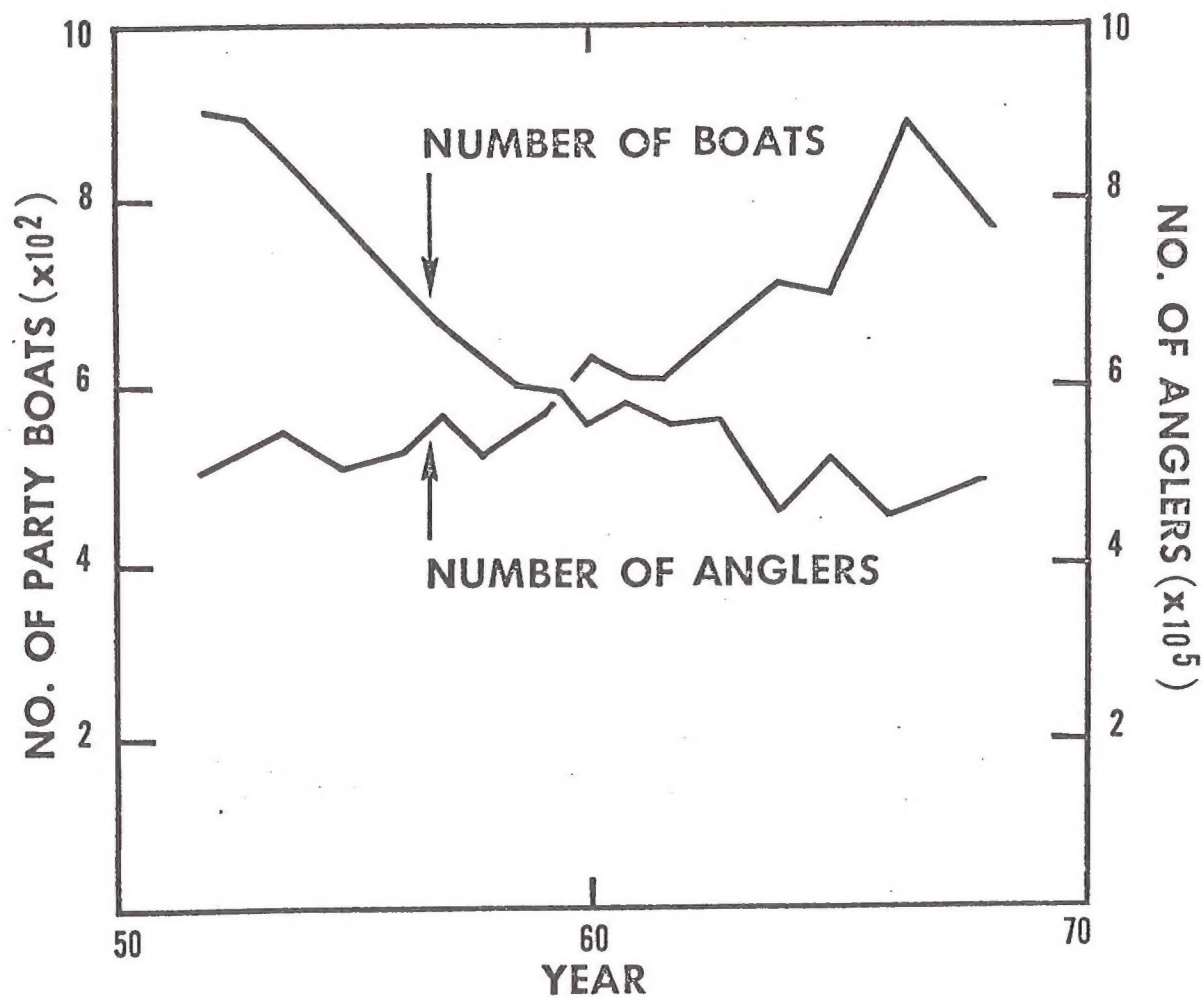


Figure II-90 Annual number of California partyboats and anglers, 1953-1967. (from Frey, 1971).

ornia, and the number of boats operating in the region is slightly higher than in the rest of the state (Miller and Hardwick, 1973). Southern California boats are larger and there are more operations of half-day boats compared with northern areas. The fishery extends from shallow areas to depths in excess of 600 feet and includes a wide variety of species, whereas in the northern and central areas partyboat fishermen rarely fish below 300 feet (Miller and Hardwick, 1973).

In the partyboat catch of central and northern California, rockfish contributed from 71.7% to 90.0% of the total catch by numbers of fish from 1955 through 1971 (Figure II-91) with salmon, lingcod, and striped bass the only other species consistently contributing significantly to the catch. In Southern California, rockfish have contributed from 9.0% to 57.2% of the total catch in the same time period (Figure II-92) with kelp and sand bass, Pacific bonito, and barracuda as the other species making up significant portions of the total catch. However, Southern California rockfish landings have exceeded those for the rest of the state since 1964 (Miller and Hardwick, 1973). Rockfish have gradually become the predominant forms in the statewide partyboat catch in the period from 1962 to 1971 (Oliphant, personal files, 1974). In 1962, rockfish constituted only 26% of the total sportfish catch, whereas in 1972 this group made up 56% of the catch.

Based on data presented by Oliphant, personal files (1974), the statewide partyboat catch has fluctuated in the period from 1962 to 1972 from a low of 3.6 million fish to a high of 5.7 million in 1968

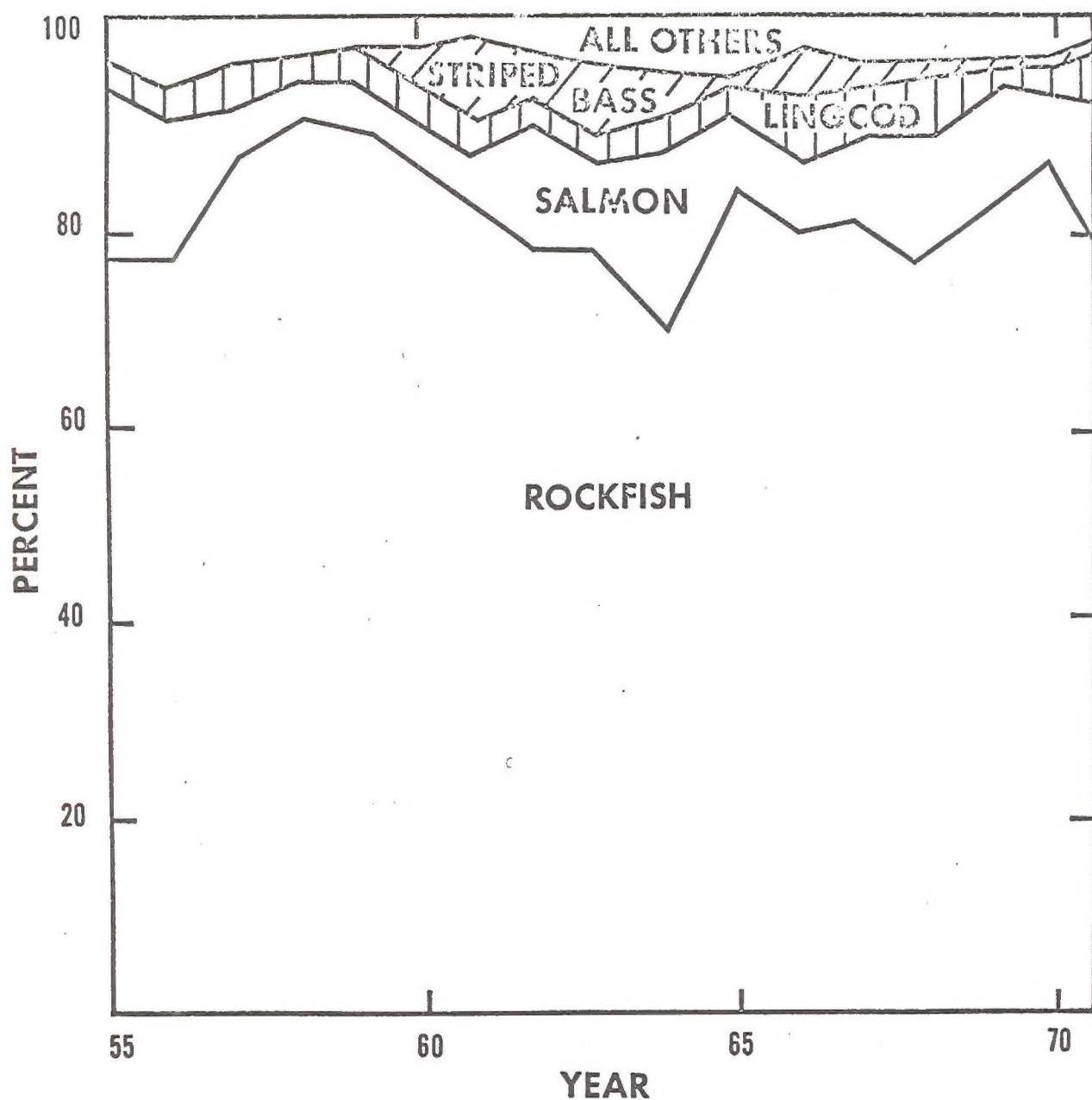


Figure II-91 Annual percent composition by numbers of the central and northern California (Avila to Crescent City) partyboat catch, 1955-1971. (from Miller and Hardwick, 1973).

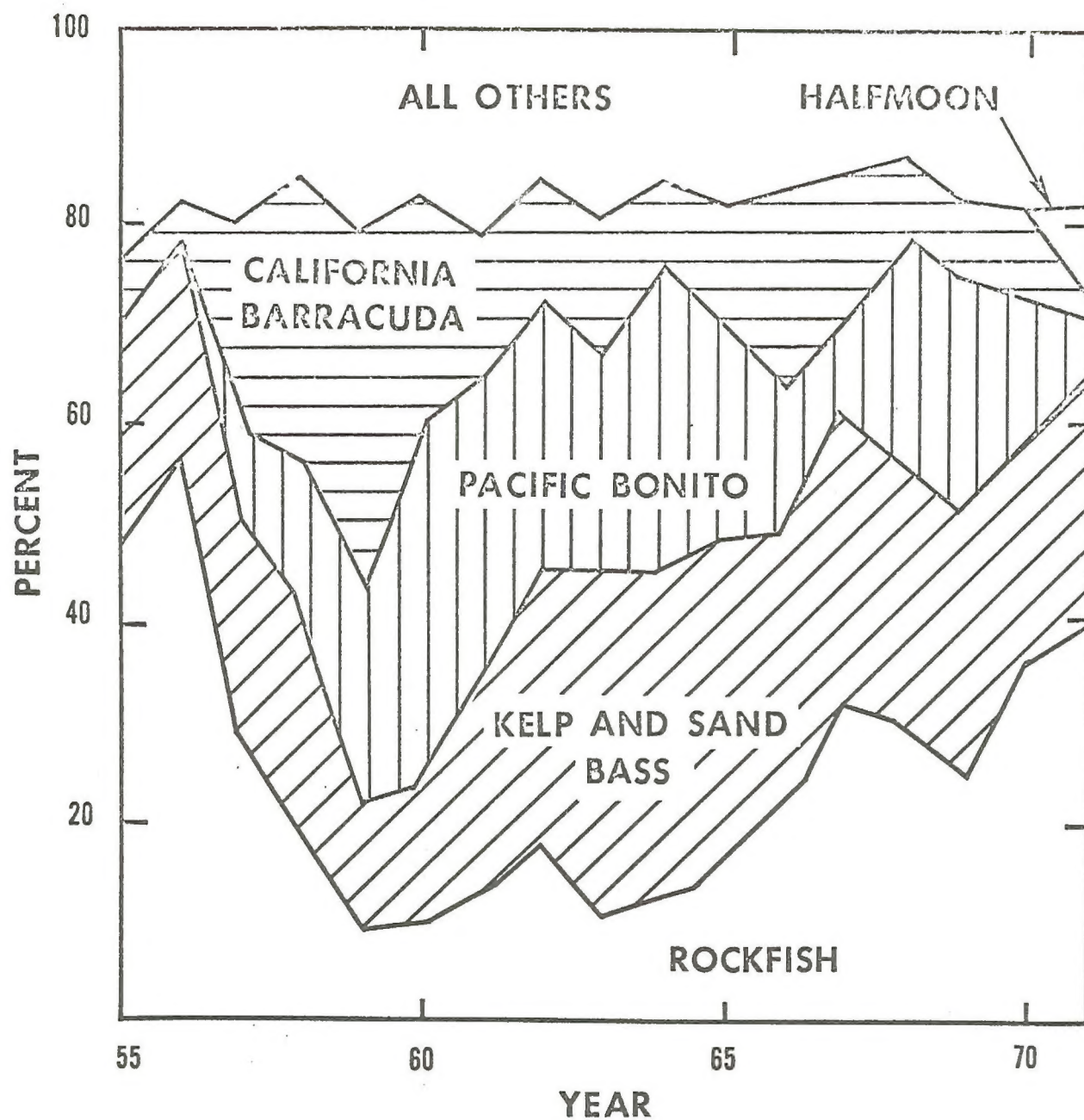


Figure II-92 Annual percent composition by numbers of the southern California partyboat catch, 1955-1971. (from Miller and Hardwick, 1973).

and 1969. The mean number for the 1962-1971 period was 4.8 million fish and the fish/angler ratio ranged from 5.7 in 1967 to 7.1 in 1969. These data show that the 1972 catch of the California barracuda was only 10% of the 1970 total. Information is not yet available to predict whether this decrease represents long-term trends or short-term fluctuations. Table II- 64 shows the latest (1972) partyboat landings for Southern California (Oliphant, personal files, 1974). The rockfish remains the principal fish, comprizing half (48%) of the partyboat fishery.

The Marine Fisheries Statistics Staff of the California Department of Fish and Game has for the past several years compiled a record of the annual sport catch by partyboats from each of a series of 10 x 8 nautical mile blocks in California waters. These unpublished data include the number of each species landed for each month from each block and the amount of fishing effort expended. Figure II-93 is a summary of the 1972 data for Southern California and shows the areas where the largest catches occurred, and the principal species landed in each area. Graphic 8 shows the combined 1971 and 1972 partyboat catch. Both figures indicate that most sport fishes are caught relatively close to the mainland or to the offshore islands. The blocks having the largest catch during 1971 and 1972 were the western area of the Palos Verdes Peninsula, near Santa Monica Bay (block #720), the eastern edge of Santa Catalina Island (block #761), and northern San Diego (block #860).

Information on the three other main types of sportfishing are less up-to-date and comprehensive and more difficult to obtain than

Table II-64

REPORT OF THE CALIFORNIA PARTYBOAT FLEET, 1972 (from OLIPHANT, 1974, personal files)

SPECIES	S.Diego Mission Bay	Dana Harbor O'side	Hunt.B. Newport Balboa	S.Pedro Long Beach	Malibu Red.Bch. S.Monica	Sta.Barb. Port Hueneme	TOTAL SOUTHERN CALIF.
Rockfish	148,029	51,037	118,602	321,284	726,580	568,951	1,934,483
Kelp & sand bass	100,140	125,698	121,743	255,106	116,854	123,140	842,681
Pacific bonito	90,385	83,616	71,712	87,246	79,122	6,525	418,606
Pacific mackerel	114,803	49,762	44,773	27,189	8,700	614	245,841
Halfmoon	8,748	1,149	12,994	62,896	40,118	33,732	159,637
Salmon	12	8	6	7	12	57	102
Lingcod	4,073	131	128	277	157	7,809	12,575
Albacore	75,544	550	100	31	...	125	76,350
Sculpin	6,566	13,237	16,908	19,610	7,635	1,921	65,877
Yellowtail	52,976	724	189	2,036	2,382	724	59,031
White croaker	68	21,883	12,999	1,792	30	250	37,022
Barracuda	24,473	4,311	941	4,549	3,420	549	38,243
Sheephead	6,778	2,738	3,209	8,527	1,805	10,482	33,539
Striped bass	...	...	...	...	...	...	...
Ocean whitefish	5,602	1,209	1,823	6,109	1,879	7,993	24,615
Misc. flatfish	1,221	536	166	1,929	2,167	3,656	9,675
Sablefish	10	98	1,080	662	9,160	497	11,507
Cabazon	421	317	437	258	374	1,722	3,529
Calif. halibut	1,604	2,066	571	1,307	944	1,360	7,852
Jack mackerel	2,186	48	483	403	625	88	3,833
Croaker	15	3,957	2	1	...	21	3,996
White seabass	1,849	252	323	874	333	205	3,836
Bluefin tuna	1,436	17	3	1	...	1	1,458
Sturgeon	...	...	...	...	...	...	...
All others	19,825	3,721	5,262	2,202	1,761	1,107	33,878
TOTAL FISH	666,764	367,065	414,454	804,296	1,004,058	771,529	4,028,166
TOTAL ANGLERS	166,000	64,227	50,913	92,366	111,115	68,052	552,673
TOTAL BOATS	100	16	24	59	13	35	247

NOTE: Smaller ports not listed separately are included in neighboring areas.

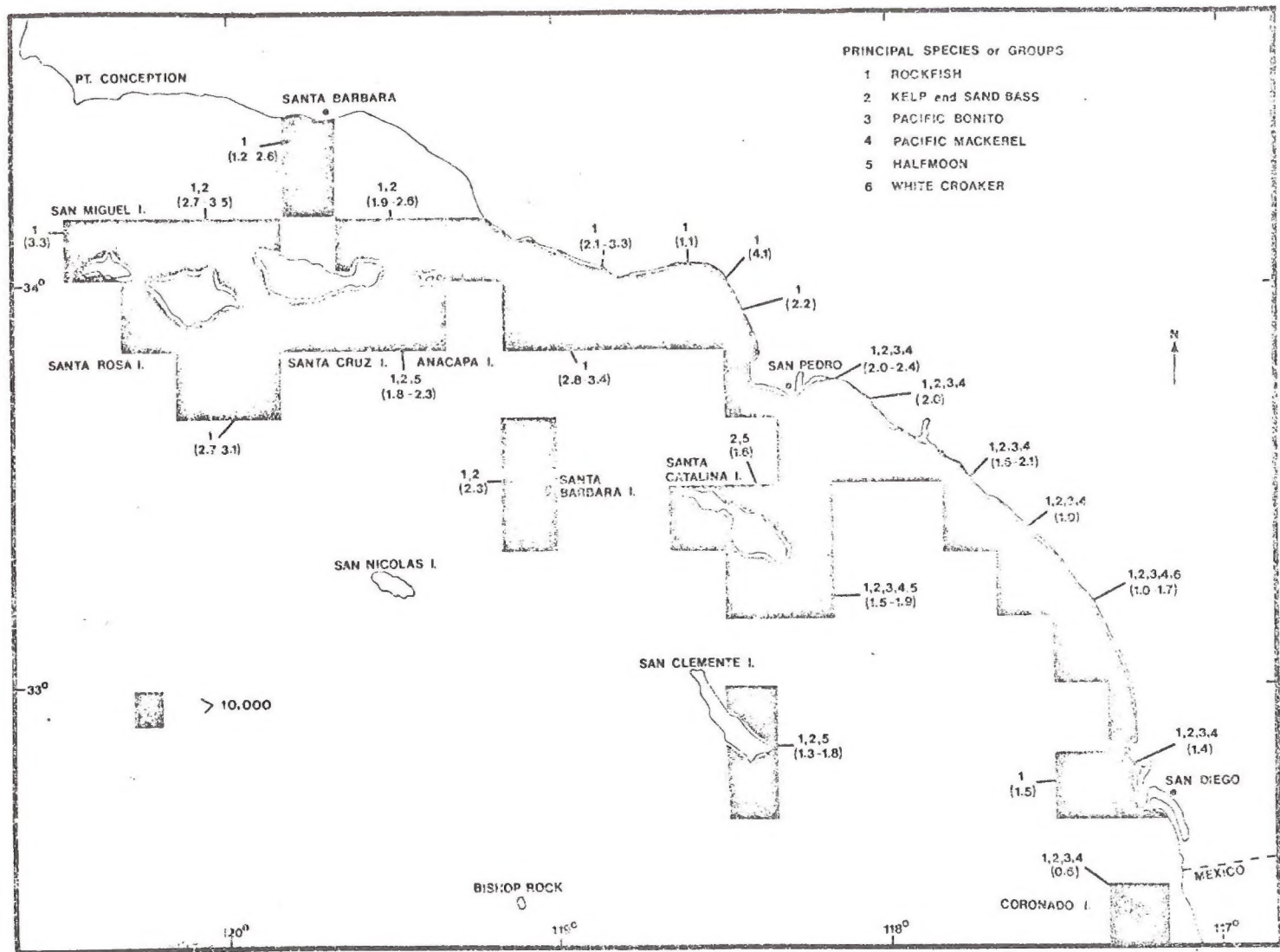


Figure II-93. Areas of concentration of sport fish landings by partyboats in Southern California waters for 1972. Principal species are referred to by number. The number or range of numbers in parentheses is the fishing effort for selected areas (number of fish/angler hour). (from Report VI (unpublished), species and effort by month and origin, compiled by the Marine Fisheries Statistics Staff, Calif. Dept. Fish & Game).

that for partyboat fishing. For the period 1963 to 1966, Pinkas, et al. (1968) provided a numerical ranking of the 15 most important sport-caught fish in Southern California waters for each type of fishing (Table G3-1, App. 10, G.3). The ranking readily identifies the relative importance of species of different habitats to the sportfishery. For both partyboats and private boats, kelp and sand bass, Pacific bonito, and rockfish were important species. For both pier and jetty fishing and fishing in inland bays, white croaker and queenfish were principal species. For open coast shoreline angling, the surfperches were the most important group. Pacific bonito and bass (kelp and sand) were the most frequently caught species for all types of sport-fishing in Southern California during the period 1963 to 1966.

Pinkas, et al. (1968) compared the four main types of sport-fishing in Southern California (Table II-65) and found that partyboats accounted for nearly 55% of all sport-caught fish. Partyboats also had the highest catch-per-man hour of fishing (1.429) while shoreline fishing has the lowest (0.305).

Skin diving and scuba diving form a fifth and expanding type of sportfishing. There has been a steady increase from 1958 (the first year records were kept) to the present in the number of divers on charter boats. In 1960, 1,239 divers used charter boat facilities and by 1970 the number had grown to 23,656 (Duffy, 1973). Diving logs obtained from California partyboats over the period 1965 to 1970 show that 83,996 divers landed 199,466 fish, mollusks, and crustaceans, averaging 2.4 animals per diver (Young, 1973a). The six-year catch was dominated by abalones (54 to 59% of the total catch),

Table II-65

SUMMARY OF SPORTFISHING EFFORT, CATCH, CATCH-PER-UNIT-OF-EFFORT IN
SOUTHERN CALIFORNIA MARINE WATERS (from PINKAS, et al. 1968)

Fishery	Man or angler days	Man hours	Numbers of fish	Catch-per-man hour of fishing ¹
Party boats (avg. 1963-66)	570,477	2,797,250	3,997,839	1.429
Piers and Jetties (1963)	1,404,079	5,090,523	1,844,970	0.362
Private boats (1964)	443,258	2,773,405	981,460	0.354
Shore line (1965-66)	551,151	1,646,289	501,734	0.305
TOTALS	4,379,203	12,307,467	7,326,003	0.595

¹
Calculated from adjusted estimates.

spiny lobster (12 to 17%), rock scallop (10 to 15%), sheephead (8 to 9%), and kelp bass (4 to 6% of the total). These data indicate the much greater interest of divers in shellfish than in finfish. Southern California offshore islands were most favored by divers, with Santa Catalina and Santa Cruz islands supporting the bulk of the diving effort. According to Young (1973a), three species, rock scallop, sheephead, and giant sea bass, are relatively vulnerable to divers and could be overexploited.

No information is available on the effort expended by sports divers operating from the shoreline or private boats. It is known, however, that divers take spiny lobster and other species and that the number of divers annually certified is increasing. By 1970, the Los Angeles County Department of Parks and Recreation was certifying about 10,000 divers per year (Duffy, 1973). In addition, many other organizations and institutions train divers in all Southern California coastal counties.

Major sportfishing areas have been briefly described and principal sport species listed for each of the five coastal counties (Santa Barbara, Ventura, Los Angeles, Orange, and San Diego) of Southern California in a recent publication by California Department of Fish and Game (1973). Annual angler days and estimated expenditures by sport fishermen in the five counties are also provided in the report and are listed in Table II-66. An increase of about 25% in angler days from 1970 to 1980 is projected and indicates that careful management of sportfishing areas and stocks will be required. This paper is further summarized below.

Table II-66

ANNUAL NUMBER OF ANGLER DAYS AND ESTIMATED EXPENDITURES OF SPORT FISHERMEN
IN THE FIVE COASTAL COUNTIES OF SOUTHERN CALIFORNIA (from California
Department of Fish and Game Planning Team, 1973)

COUNTY	ANGLER DAYS (Annual average)		ESTIMATED EXPENDITURES, 1970
	1970	1980 (Projection)	
Santa Barbara	187,500	236,300	\$ 2,294,000
Ventura	662,500	834,800	8,104,000
Los Angeles	2,875,000	3,622,500	35,166,000
Orange	2,700,000	3,400,000	32,800,000
San Diego	1,200,000	1,500,000	14,700,000
TOTALS	7,625,000	9,593,600	\$93,064,000

Principal Commercial and Sport Groups of Fish and Shellfish

This section provides in tabular form (Table II-67) a summary of the rank in the 1972 commercial landings, the type of fishery, the state of utilization, and the partyboat rating of 15 groups of fish and shellfish presently comprising most of the fisheries resources in the waters off Southern California. The basis for the table is data from Frey (1971). Papers by Ahlstrom (1968) on the state of utilization of fishery resources, by Young (1969) on the partyboat fishery, and by a series of authors who summarized the status of eleven groups or species as part of the proceedings of a recent (12-15 March 1973) marine fisheries workshop (Squire, 1973) were also of importance in formulating Table II-67.

Socioeconomic Comparison of Commercial Fishing and Sport Fishing

Commercial fishing and sport fishing are important industries providing employment for a considerable number of people and bringing large revenues into the state. The two industries are utilizing the same marine waters off Southern California (except that most tunas are caught outside of California waters), and frequently fishing for the same species of fish or shellfish. Young (1969) pointed out that of the 20 most important gamefish as rated by Southern California partyboat operators in 1968, all except one entered into the commercial fishery. The data of Table II-67 indicates that most of the fishery species listed are sought by both sport and commercial fish-

Table II-67
UTILIZATION AND STATUS OF THE PRINCIPAL GROUPS OF COMMERCIAL
AND SPORT FISH AND SHELLFISH IN SOUTHERN CALIFORNIA (from Horn, 1974b)

Group and Species	Type of Fishery ¹	Rank in 1972 Commercial landings ²			Party boat Rating ³	State of Utilization ⁴	References on Status
		LA	SD	SB			
Echinoderms Sea Urchins	C						Kato (1972)
Crustaceans Spiny Lobster	C,S	16	9	16		Overutilized	Frey (1971) Duffy (1973)
Rock Crabs	C,S	11	15	12		Moderately underutilized	Frey (1971)
Pelagic Red Crab	C					Much under- utilized	Frey (1971)
69 Mollusks							
Abalones	C,S	12	7	6		Overutilized	Frey (1971)
69 Squid	C	8		3		Moderately underutilized	Frey (1971)
Sharks, Rays, and Skates	C,S	27	12	18		Much under- utilized	Frey (1971)
Pelagic Wetfish Northern Anchovy	C	2	28	1		Moderately under- utilized	Frey (1971) Ganssle (1973)
Pacific Sardine	C	14	15			Commercial Moratorium	Frey (1971) Haugen (1973)
Jack Mackerel	C,S	3		7		Much Under- utilized	Frey (1971) Knaggs (1973)
Pacific Mackerel	C,S	24	24			Commercial Moratorium	Frey (1971) MacCall (1973)
Pacific Saury	C,S					Much Under- utilized	Frey (1971)
Flatfish California Halibut	C,S	28	18	15	5	Fully utilized	Frey (1971)

Table II-67 (Continued)

Group and Species	Type of Fishery ¹	Rank in 1972 Commercial landings ²			Party boat Rating ³	State of Utilization ⁴	References on Status
		LA	SD	SB			
Dover Sole	C			14		Moderately underutilized	Frey (1971)
English Sole	C			11		Moderately underutilized	Frey (1971)
Petrale Sole	C			18		" "	Frey (1971)
Rex Sole	C			19		" "	Frey (1971)
Sanddabs	C					" "	Frey (1971)
Rockfish	C,S	10	6	4	6	" "	Frey (1971) Miller and Hardwick (1973)
Pacific Hake	C					Much under- utilized	Frey (1971) Jow (1973)
Sablefish	C,S				19	Much under- utilized	Frey (1971)
Tunas							
Yellowfin	C,S	1	1			Fully utilized	Frey (1971)
Skipjack	C,S	4	2			Moderately underutilized	Frey (1971)
Albacore	C,S	7	4	2	7	Fully utilized	Frey (1971)
Pacific Bonito	C,S	5	5	5	4	Moderately under- utilized	Frey (1971) Thayer (1973)
Bluefin	C,S	6	3		9	Fully Utilized	Frey (1971)
Black Skipjack	C,S	9	11				
Billfish							
Swordfish	C,S	22	13	22			Frey (1971)

Table II-67 (Continued)

Groups and Species	Type of Fishery ¹	Rank in 1972 Commercial landings ²			Party-boat Rating ³	State of Utilization ⁴	References on Status
		LA	SD	SB			
Striped Marlin	S						Frey (1971)
Nearshore Game Fish							
Kelp and Sand Bass	S				2		Frey (1971)
Giant Sea Bass	C,S	25	20		12		Frey (1971)
California Barracuda	C,S		23		1		Frey (1971)
							Schultze (1973)
California Yellowtail	C,S	18	14		3		Frey (1971)
							Collins (1973)
Sculpins and Greenlings							
Cabezon	C,S				17		Frey (1971)
Lingcod	C,S			9	14		Frey (1971)
Croakers							
White Seabass	C,S	13	8	17	8		Frey (1971)
							Young (1973b)
White Croaker	C,S	15	27		20		Frey (1971)
Surfperch	C,S	21	17	26			Frey (1971)

1 C = Commercial, S = Sport

2 From Bell 1974; LA = Los Angeles, SD = San Diego, SB = Santa Barbara

3 From 1968 ratings of the 20 most important game fish species by eleven Southern California partyboat landing operators (Young, 1969).

4 Based on qualitative ratings by Ahlstrom (1968) and updated from personal communication with California Fish and Game workers.

ermen. Several species such as white seabass, yellowtail, and spiny lobster have dual regulations and other species, such as kelp and sand bass may not be fished commercially in California waters. This kind of dual utilization of resources by commercial and sport interests can lead to conflicts of interest and requires interaction and close cooperation between the two industries.

A second type of conflict between the two industries may occur when a commercial species is forage for sportfishes. An example is the northern anchovy which is the most important species in the commercial fishery, but which is also important food for several species of game fish upon which the sportfishing boats depend. Thus, sportfishermen protested when the California Game and Fish Commission recently granted the commercial fishing industry permission to take an additional 20,000 tons of anchovies from Southern California waters over the normal seasonal quota of 100,000 tons which had already been reached (Los Angeles Herald-Examiner article, 12 March 1974). Conflicts such as this and others make the comparative economic value of commercial and sportfishing important information for decision-makers to have regarding regulation of fisheries and the management of resources.

Gruen, Gruen and Associates (1972) in a socioeconomic analysis of California's sport and commercial fisheries concluded that in terms of net economic value, total sport fishing (including inland fishing) contributes more to California than total commercial fishing (including inland fishing)-- \$100 to \$200 million for sport fishing as compared to about \$43 million for commercial fishing (Table II-68).

Table II-68

NET ECONOMIC VALUE OF COMMERCIAL FISHING AND SPORT FISHING
IN CALIFORNIA, 1970 (from GRUEN, GRUEN, AND ASSOCIATES, 1972)

<u>Commercial Fishing</u>			
	<u>Gross Landed Value</u>	<u>Assumed Proportion</u>	<u>Net Economic Value</u>
Tuna caught in out-of-State waters	\$56,710,695	0.5	\$28,355,347
Other Marine Species	29,689,634	0.5	14,844,817
Inland	312,738	0.5	156,369
Total Marine and Inland	\$86,713,067	0.5	\$43,356,533

<u>Sport Fishing</u>			
	<u>Angler Days</u>	<u>Assumed Value Per Day</u>	<u>Net Economic Value</u>
Marine.	11,910,000	\$2	\$ 23,820,000
	11,910,000	\$3	35,730,000
	11,910,000	\$4	47,640,000
Inland	38,370,000	\$2	76,740,000
	38,370,000	\$3	115,110,000
	38,370,000	\$4	153,480,000
Total, Marine and Inland	50,280,000	\$2	100,560,000
	50,280,000	\$3	150,840,000
	50,280,000	\$4	201,120,000

If, however, inland fishing is excluded from both types, and strictly marine sport and commercial fishing are compared, the net economic values are similar -- \$23 to 47 million for sport fishing and \$43 million for commercial fishing. On the other hand, if tunas caught in out-of-state waters are excluded, the marine commercial value becomes substantially lower than the marine sport value even at only \$2 per angler day -- about \$24 million for sport fishing versus about \$15 million for commercial fishing.

Gruen, et al. (1972) made clear that their valuation of California's two uses of fish cannot be precise owing to the weaknesses in existing data and to problems of measurement method peculiar to fish resources. They further pointed out that their comparison does not legitimately make it possible to conclude that any particular species is worth more to sport fishing than to commercial fishing.

An estimate by Gruen, et al. (1972) of marine sportfishing activity in California for 1970 is given in Table II-69. They expressed lack of confidence in their breakdown of the relative magnitude of the types of sport fishing, but indicated that the data did show the greater importance of Southern California as compared with the rest of the state, and of pier, jetty, and shoreline fishing as compared with other types of sport fishing. Their data reveal a considerable increase in the importance of pier, jetty, and shoreline fishing in terms of angler days over that presented by Pinkas et al. (1968) for 1963-1966 (Table II-65).

Appendix 10, G.3 contains a coastal county summary of sport fishing facilities compiled by the California Department of Fish and Game (1973).

Table II-69

ESTIMATE FOR 1970 OF MARINE SPORT FISHING ACTIVITY BY
GEOGRAPHICAL AREA AND TYPE OF FISHING IN ANGLER DAYS
(from GRUEN, GRUEN, AND ASSOCIATES, 1972)

	<u>Central and Northern California</u>	<u>Southern California</u>	<u>Total</u>
Piers and jetties	1,832,088	3,730,395	5,562,483
Shoreline	2,074,895	1,467,877	3,542,772
Partyboats	182,235	691,092	873,327
Private Boats	419,394	1,180,924	1,600,318
Other	132,440	198,660	331,100
 TOTAL	 4,641,052	 7,268,948	 11,910,000

4. Ports and Shipping

California has numerous ports for handling of container, bulk, general and liquid cargoes. The ports extend from San Diego in Southern California to the Port of Crescent City which is located near the California-Oregon border. General information for ports in the proposed leasing areas in Southern California Borderland is tabulated below.

The vessel arrivals and departures for calendar year 1973 were:

<u>PORT</u>	<u>VESSEL ARRIVALS</u> ^{1/}	<u>VESSEL DEPARTURES*</u>
San Diego	1,823	1,820
Long Beach	6,284	6,274
Los Angeles	12,707	12,721
Port Hueneme	945	946
Santa Barbara	202	202
Carpinteria	39	39
El Segundo	336	333
Encina	59	60
Huntington Beach	25	24
Ventura Harbor	107	108

1/ Excludes domestic fishing crafts

Source: Department of the Army-Corps of Engineers,
Waterborne Commerce of the United States
Calendar Year 1973, Part 4, Waterways and
Harbors Pacific Coast, Alaska, and Hawaii

Total freight traffic through the ports for calendar
year 1973 was:

<u>PORT</u>	<u>TOTAL WATERBORNE TONNAGE</u> (Short Tons 2,000 pounds)
San Diego	2,063,356
Long Beach	27,133,022
Los Angeles	25,977,491
Port Hueneme	1,109,381
Newport Bay	58
Redondo Beach	94
Santa Barbara	4,933
Carpinteria	430,177
El Segundo	8,678,770
Encina	1,052,973
Huntington Beach	739,406
Ventura Harbor	1,938,939

Source: Department of the Army - Corps of Engineers,
Waterborne Commerce of the United States
Calendar Year 1973, Part 4, Waterways and
Harbors Pacific Coast, Alaska, and Hawaii

Value of exports and imports through California ports, by customs district, by all modes of transportation, for calendar years 1972 and 1973 were:

<u>Exports</u>	<u>1972</u>	<u>1973</u>
California	\$4,152,600,000	\$6,647,200,000
San Francisco ^a	1,839,300,000	2,945,600,000
Los Angeles ^b	1,973,200,000	3,277,000,000
San Diego ^c	310,100,000	424,000,000

<u>Imports</u>	<u>1972</u>	<u>1973</u>
California	\$6,508,800,000	\$8,607,200,000
San Francisco ^a	1,871,100,000	2,501,900,000
Los Angeles ^b	4,289,500,000	5,651,800,000
San Diego ^c	348,200,000	453,500,000

a. Includes the Ports of Eureka, Carquinez Strait, San Pablo Bay, Richmond, Oakland, Redwood City, San Francisco, Moss Landing, Monterey, San Joaquin River, Stockton, Sacramento, Suisana Bay Channel, Crescent City, and other San Francisco coastal ports.

b. Includes the Ports of Los Angeles, Long Beach, Newport Bay, Santa Barbara, Morro Bay, El Segundo, Santa Monica, Port Hueneme, Ventura, Carpinteria, Ellwood, Capitan, Gaviota, San Luis Obispo, Estero Bay, Avalon, Huntington Beach, Encina, and other Los Angeles ports.

c. Ports of San Diego.

Source: California Statistical Abstract, 1974

Inquiries have been directed to the United States Coast Guard regarding the total number of ships sailing within the Southern California Bight on an annual basis. The Coast Guard indicated that

the total number of ships data is not maintained. The above information provides some insight into the traffic volume, but does not include military shipping, pleasure boats, or through traffic.

5. Commercial Biological Resources

The following section comes, with minor changes, from Horn (1974b) except for the following subsections: Current Status and Recent Trends (in part); Fishing Gear; Shellfish; Kelp and Algae Resources; County by County Summary; and Mexican and Foreign Fisheries. Impacts on commercial fishes may be found in Section III.E.1-3 of the EIS.

a. Introduction and Overview

The Southern California Bight has a history as an important center in the United States for both commercial and sport fishing interests, reflecting the environmental heterogeneity and high diversity of fishes in the region. California has claimed a significant share of the value of the United States fish landings (25% in 1950, 17% in 1968, Frey, 1971) and Los Angeles (San Pedro) was in 1972 by far the leading port in the U. S. for both weight and value of landings (Anonymous, 1973). Both the commercial and sport fisheries have a history of fluctuation regarding certain individual species. During the last 20 years, although there has been a general stabilization, commercial landings in Southern California have declined (Figure II-94). Conversely, sport landings have increased (Figure II-95).

Almost all sport and commercial fish landed in Southern California waters are either pelagic fishes, taken by a variety of methods, or inshore predatory fishes, such as halibut and rockfishes, caught by selective hook-and-line fishing. South of Point Mugu bottom fish caught by trawling represent an insignificant fraction of the total catch.

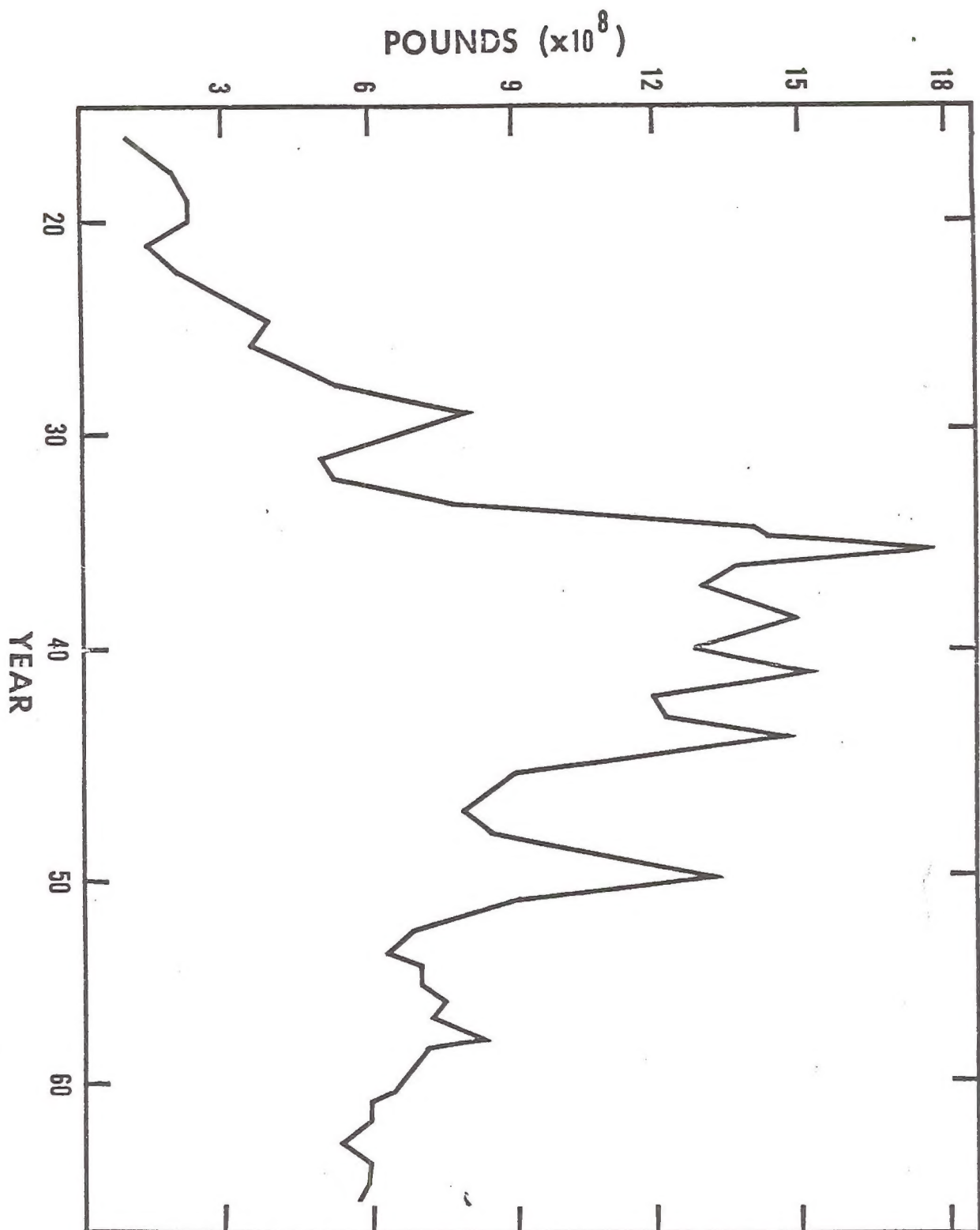


Figure II-94. Total annual commercial landings and shipments of fish and shellfish into California, 1916-1968. (from Heilmann and Carlisle, 1970).

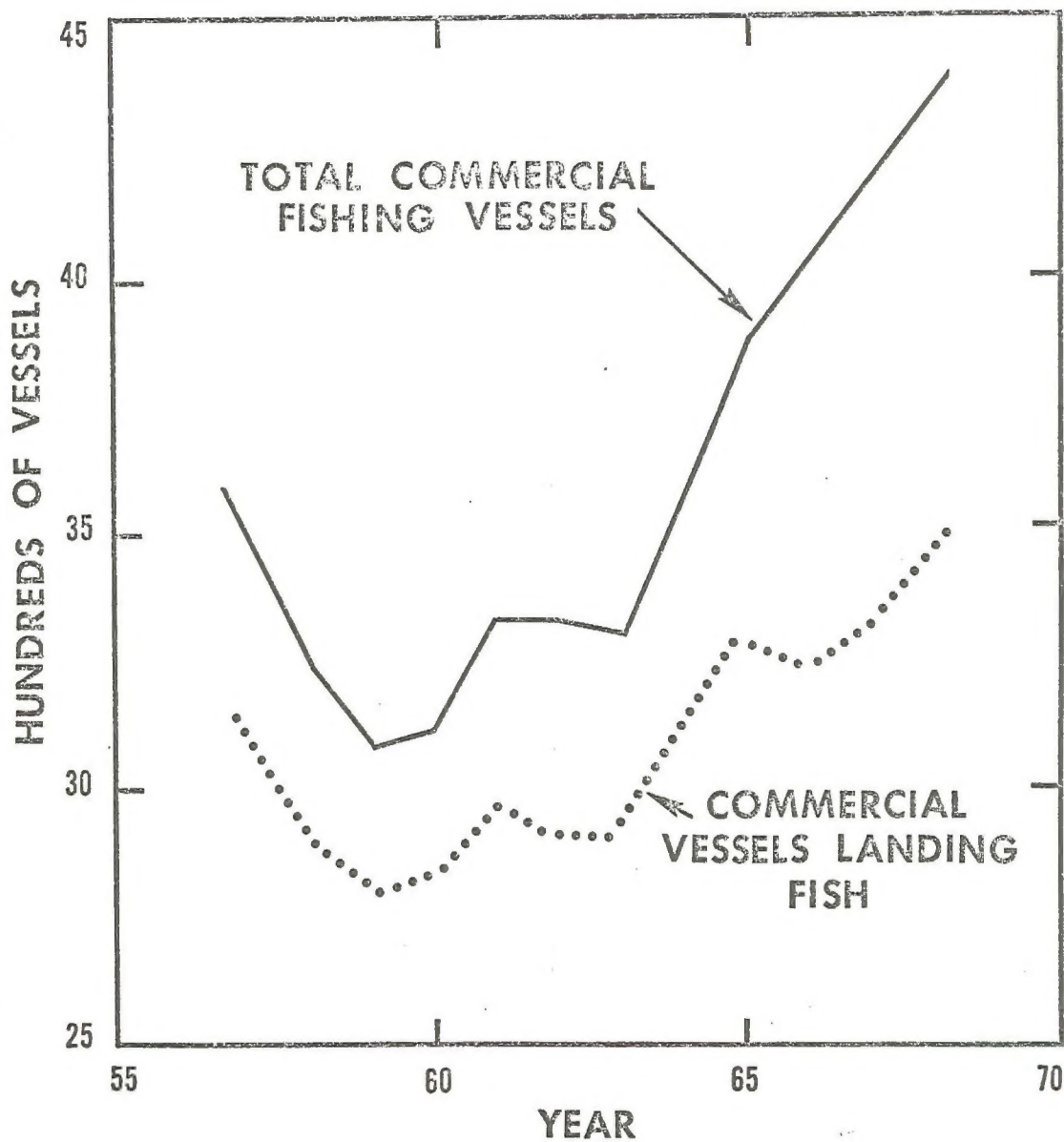


Figure II-94a. Annual number of California registered commercial fishing vessels and the number of commercial vessels landing fish, 1957-1968. (from Frey, 1971).

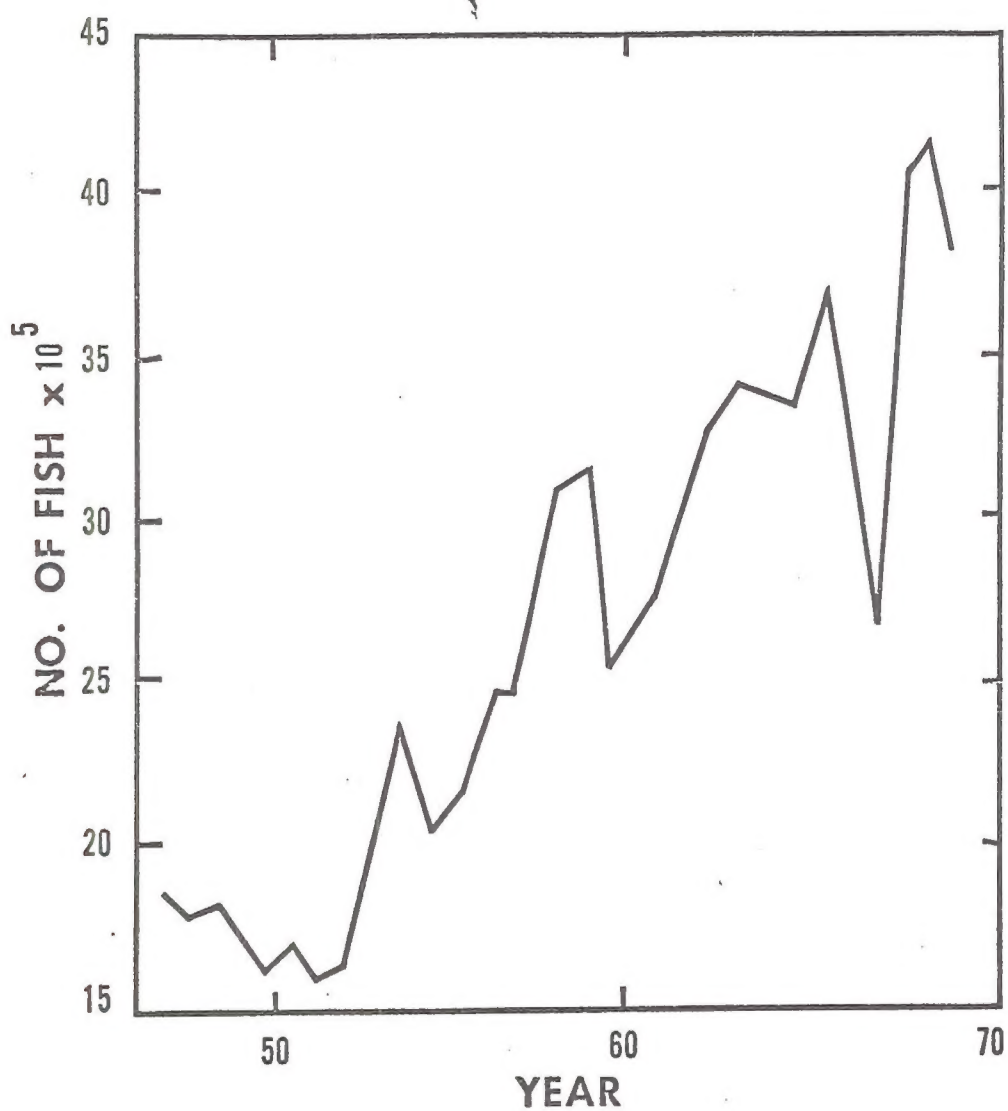


Figure II-95 Total number of fish caught by party boats in southern California waters, 1947-1970. (from SCCWRP, 1973; after Young, 1969).

North of Point Mugu, to Point Arguello, is a region which the California Department of Fish and Game refers to as the California halibut trawling grounds, and commercial trawling is permitted within one mile from shore to a depth of 25 fathoms (about 50 meters). Santa Monica Bay is closed to commercial fishing of all kinds except those using extremely small nets for sportfish bait. Unlike Southern California, trawling and long line fishing in the central and northern portions of the state account for a large portion of the fish landed (SCCWRP, 1973).

Commercial fishing in Southern California has largely consisted of pelagic wetfish (sardine, anchovy, Pacific mackerel, and jack mackerel) and tunas. When canned, pelagic wetfish are first put in the can and then cooked. This is unlike tunas, which are cooked before canning. Pelagic wetfish include anchovies, sardines, mackerels and squid. The wetfish industry has both declined and changed in species composition. Following the decline of the sardine during the period 1945 to 1952, the anchovy became and is now the most important species in the wetfish industry. The anchovy, however, is not processed as wetfish but reduced to fish meal and oil and is low, although increasing, in price. According to Stephens' (1972) calculations from Frey's (1971) data, the wetfish industry is one-sixth as productive now as in 1936. The tuna catch, likewise, has greatly decreased in size for local waters, and according to Stephens (1972), is one-half as productive today as in 1936. Tuna fishing is now a worldwide operation, and most of the fish brought to Southern California are caught off Central and South America and West Africa. About 94% of

the 1972 tuna catch was made outside of the California waters based on preliminary data compiled by Bell (1974).

The tunas: yellowfin tuna, skipjack tuna, Bluefin tuna, and Pacific bonito, dominate the list of California landings (Table G5-1, Appendix 10, Section II.G.5.). Based on data presented by Oliphant and staff (1973), tunas comprised 63% of the weight and 83% of the value of all landings and shipments into California in 1971. Accompanying the increase in long-distance tuna fishing has been the conversion from bait-and-line fishing to mechanized purse seining. In 1950, 25% of the tuna vessels in the eastern tropical Pacific were purse seiners, whereas by 1961 the figure had increased to 67% (McNeely, 1961).

United States landings of edible fishery products have remained close to 1.1 million tons a year for many years, but imports of these products have nearly doubled since 1959 from less than one million tons to 1.6 million tons (Figure II-96). The per capita consumption of edible fishery products for the United States and California has remained relatively stable over the past 30 years (Figure II-97), and there has been no significant change in the consumption pattern, although there was a seven percent increase in 1972 over 1971 (Anonymous, 1973). The fresh and frozen market accounts for 55% of total consumption, while canned fish accounts for 40% and cured fish 5% (Frey, 1971). California's consumption of edible fish averages 12.0 pounds per person and is 10% higher than the United States average, which seems to be consistent with the proximity-availability concept (Frey, 1971). In recent years, between 60 and 65% of the U. S. fish catch has been going for human consumption.

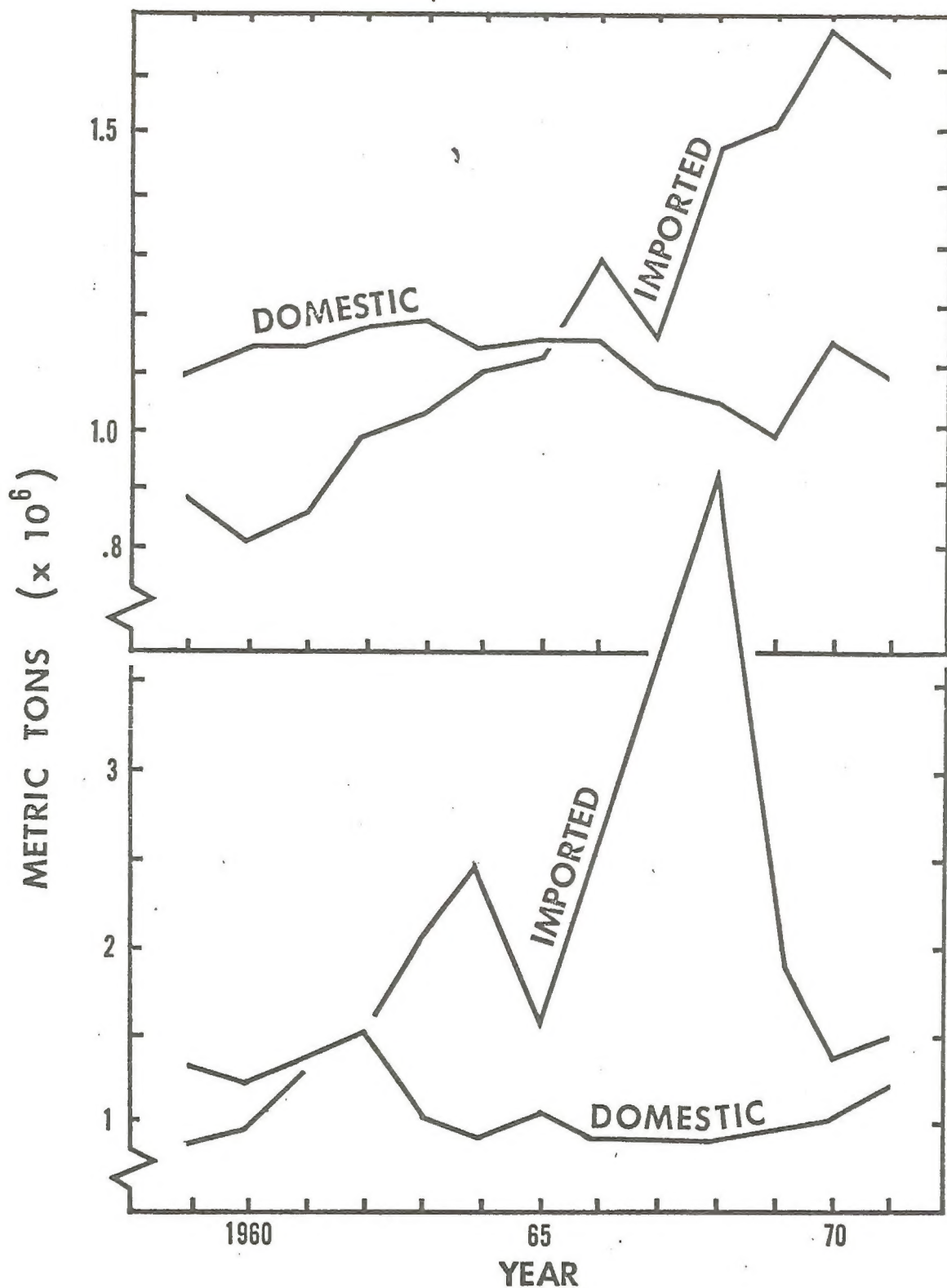


Figure II-96 U.S. supply of edible and industrial fishery products, 1959-1971. (from Wise, 1972).

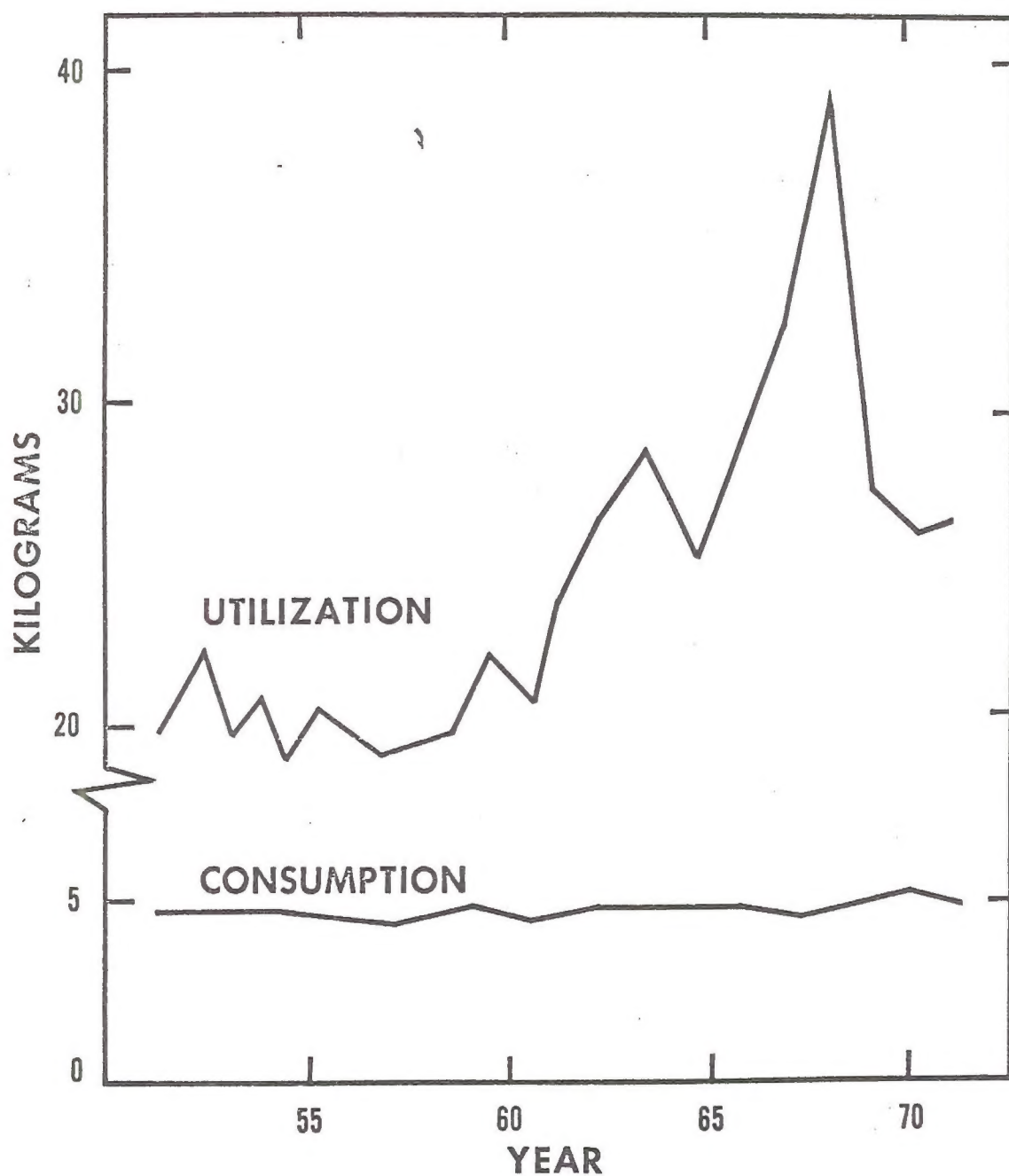


Figure II-97 Per capita consumption and utilization of fishery products in the U.S., 1951-1971. (from Wise, 1972).

Per capita utilization, which includes inedible industrial fishery products, increased from about 20 kg in the 1950's to a peak in 1968, and has remained around 25 to 26 kg through 1971 (Figure II-97). The marked fluctuations in importation and utilization of industrial fishery products (Figure II-96) are closely related to demand for fishmeal used principally as a supplement in poultry feeds (Wise, 1972).

b. Historical Aspects

Heimann and Carlisle (1970) reviewed the catch record for the years 1916 through 1968, giving the entire statistical summary of the fisheries of California since the beginning of its recorded history. Landings during the 53-year period showed an almost steady rise from 1916 to 1936 when a peak of 1.76 billion pounds of fish were landed, followed by a fluctuating decline into the early 1950's and finally followed by a slow but steady decline since 1958 (Figure II-94). Sardines dominated the landings during the 1930's and 1940's (83% of the 1936 record catch), but after the failure of this fishery in the early 1950's, the tunas have become the dominant fishery species followed by the anchovy.

Most California fishery landings since the late 1940's have been made into the southern part of the state, especially into the Los Angeles area (Figure II-98). Figure II-99 illustrates the relative importance of sardines to the total catch before 1952, and the lesser but sizeable contribution of anchovies to the total landings from 1953 to 1960 and since 1965.

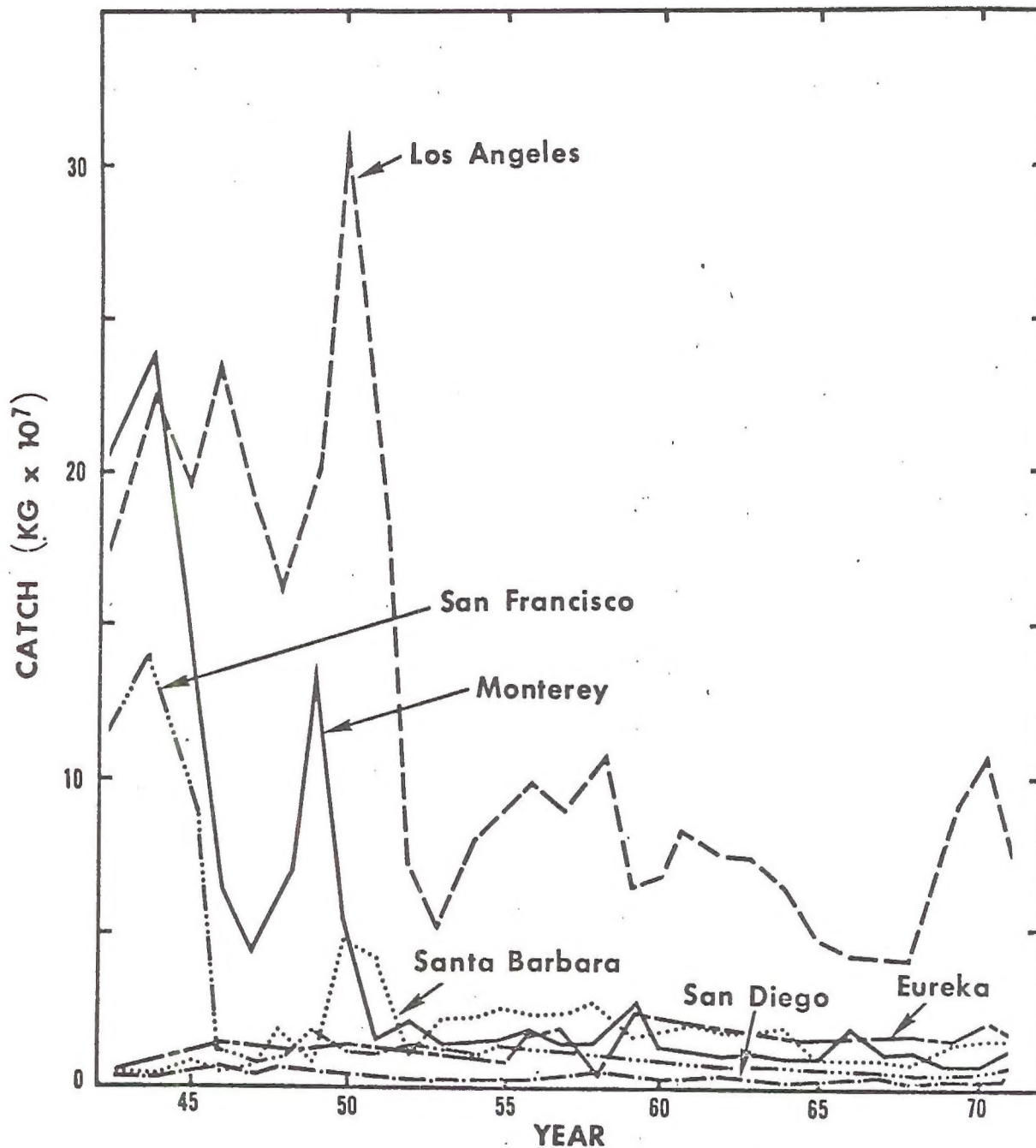


Figure II-98 California commercial fish and shellfish landings by region, 1943-1971. (from SCCWRP, 1973).

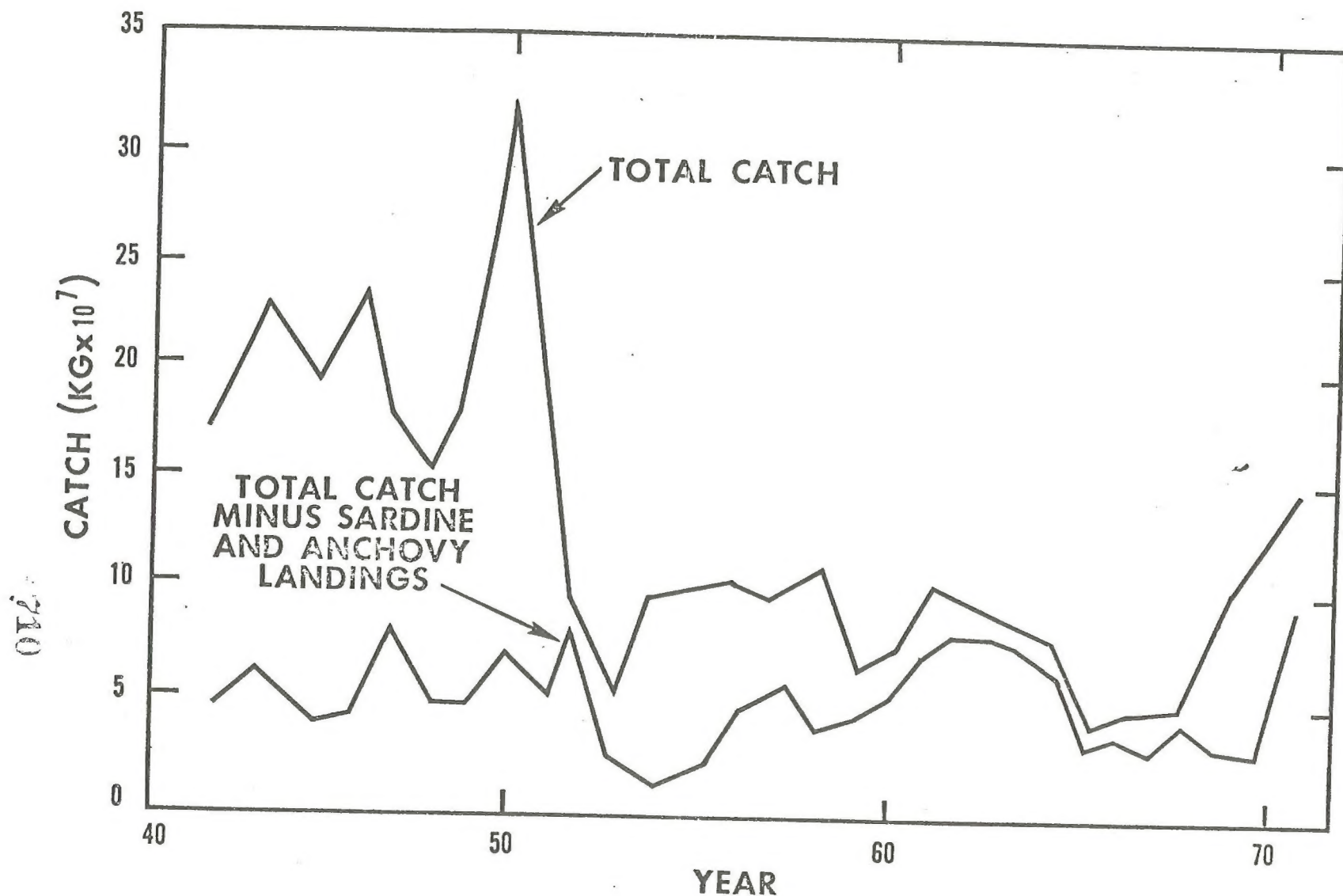


Figure II-99 Commercial fish and shellfish landings into the Los Angeles and San Diego regions from California waters, 1943-1971. (from SCCWRP, 1973).

c. Current Status and Recent Trends

The total landings by weight and dollar value and the principal months of capture of all fish and shellfish species and species groups for each of the three principal Southern California areas, Los Angeles, San Diego, and Santa Barbara, are listed in Table G5-1, Appendix 10, Section II.G.5. and ranked in order of decreasing poundage. Yellowfin and skipjack tunas are not harvested in California waters (Frey, 1971). Table G5-1 also shows the catch with the yield of these two tuna subtracted from the total of the Los Angeles and San Diego areas. Many of the tunas reported from the San Diego area were caught off Baja California. However, the assumption that fishermen from a given port concentrate their efforts in local waters is pretty valid except for the albacore and bluefin tuna, particularly at San Diego (M.S. Oliphant, personal communication).

Only the Santa Barbara area landings for 1971 and 1972 are presented with the ports north of Point Conception (Morro Bay and Airla) omitted. The landings for all commercial fish, excluding yellowfin and skipjack tuna, for Southern California are shown on Table II-70, and the 1971 and 1972 landings and dollar values of fin fish only are shown on Table II-71. It is evident from comparison of the tables that the great majority of the landings and value of commercial fisheries in Southern California are from fin fish. (Shellfish are discussed in detail below). Landings and values for the Los Angeles area accounts for higher landings than the Santa Barbara and San Diego areas combined. According to these data, commercial fisheries is a \$17 to \$66 million a year industry consisting of about 258 million pounds of

Table II-70

TOTAL COMMERCIAL FISHERY LANDINGS (EXCLUDING SKIPJACK AND YELLOWFIN TUNA) FOR SOUTHERN CALIFORNIA 1968-1972 (HORN, 1974; OLIPHANT AND STAFF, 1973; OLIPHANT, 1974, PERSONAL FILES)

<u>AREA & YEAR</u>	<u>Pounds Landed</u>	<u>Value</u>
Santa Barbara		
1968		
1969		
1970		
1971	32,736,529	\$ 1,279,654
1972	38,443,337	\$ 1,630,876
Los Angeles		
1968	115,804,271	\$ 6,901,729
1969	204,360,893	\$ 8,508,423
1970	252,588,394	\$ 8,764,653
1971	172,830,136	\$10,340,220
1972	206,448,663	\$11,435,881
San Diego		
1968	6,162,056	\$ 1,189,336
1969	9,010,523	\$ 1,582,078
1970	7,475,893	\$ 1,814,931
1971	17,017,554	\$ 4,052,445
1972	16,973,627	\$ 4,317,565

Table II-71

TOTAL COMMERCIAL FIN FISH LANDINGS FOR SOUTHERN CALIFORNIA 1971 AND 1972. (OLIPHANT, 1973, OLIPHANT, 1974, PERSONAL FILES).

<u>AREA</u>	<u>Pounds Landed</u>		<u>Value</u>	
	<u>1971</u>	<u>1972</u>	<u>1971</u>	<u>1972</u>
Santa Barbara	31,434,214	36,604,228	\$ 768,491	\$ 935,379
Los Angeles	171,512,733	205,033,211	\$ 9,938,853	\$10,807,459
San Diego	<u>16,303,752</u>	<u>16,322,538</u>	<u>\$ 3,768,594</u>	<u>\$ 3,840,875</u>
Total	219,250,699	257,959,977	\$14,475,938	\$15,583,713

fish landed in Southern California waters. This value is the money received by the fisherman. If processing, marketing, etc., were considered, the value of the industry would be much greater. The total weight and value of landings into the three areas have increased somewhat from 1968 to 1972 (Figure II-100), although the increase has not been steady in all cases. In 1972, San Pedro (Los Angeles area) was the leading port in the United States in both weight and value of landings; San Diego ranked ninth in poundage and fifth in value of landings (Anonymous, 1972). Based on preliminary data for 1972 (Bell, 1974), 86% of the fish and shellfish landed in California were brought into Southern California ports and 67% of the total into Los Angeles. About 45% of the more than 10,000 commercial fishermen licensed in 1971-72 resided in Southern California (Oliphant and staff, 1973).

Table G5-2, Appendix 10, Section II.G.5. indicates recent statewide landing trends and principal fishing methods of the major commercial species of Southern California. Table G5-3, Appendix 10, Section II.G.5. shows the Northern anchovy dominated California live bait landings sold for saltwater sportsfishing for 1968 to 1972. The average price per pound of all fish landed in the three Southern California areas reflects the relative value of tunas and anchovies. In 1971, Santa Barbara landings were 50% anchovies and averaged 7¢/lb; Los Angeles landings were 18% anchovies and average 13¢/lb; and in San Diego, where anchovies are an almost negligible percentage of the catch and tunas most important, the average price was 21¢/lb. Tuna shipments into Los Angeles and San Diego (not included in the data of Table G5-1 and Figure II-100) make these two areas even more important as fishery

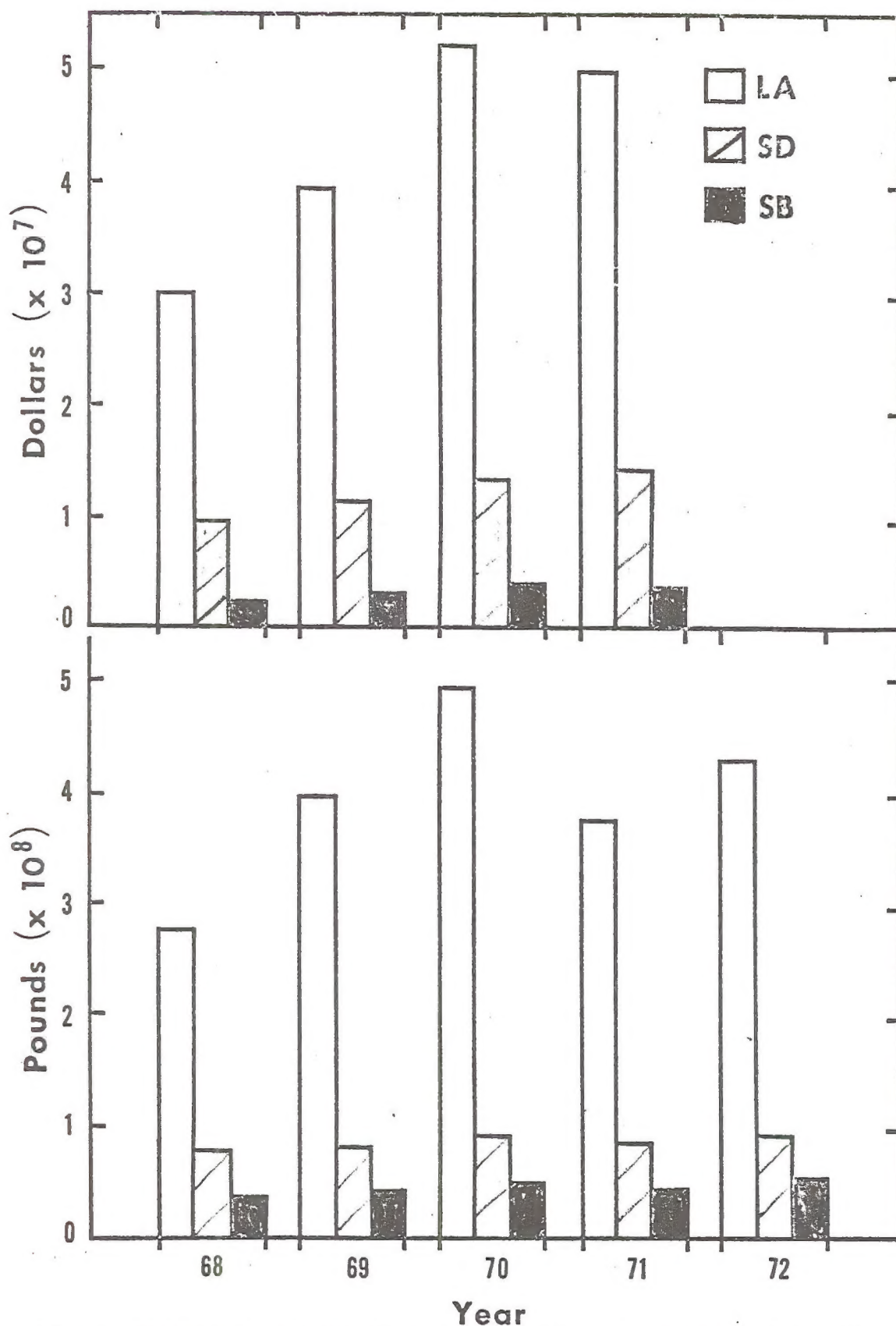


Figure II-100 Weight (lbs) and value (\$) of commercial landings of fish and shellfish into the three principal southern California regions, 1968-1972. (Weight only for 1972) (Data same as totals of Table 20-1) (from Heimann and Carlisle, 1970; Pinkas, 1970; Bell, 1971; Oliphant and Staff, 1973; Bell, 1974).

species. In 1971, for example, shipments into California were made only into Los Angeles and San Diego, and the amount shipped into Los Angeles was 96 million pounds or 20% of the total fish handled there.

For the past several years the Marine Fisheries Statistics Staff of the California Department of Fish and Game has compiled a record of the annual commercial catch from each of a series of 10 x 8 nautical mile blocks. These unpublished data include the poundage of each species landed for each month from each block. Figure II-101 is a summary of the 1972 data for Southern California and shows the areas where the largest catches occurred and the principal species captured in each area. Graphic 7, also based on catch blocks, shows the commercial catch of 1970 through 1972.

It is evident from the figures that near shore, off the Channel Islands and on Cortes and Tanner Banks, are the principal commercial fisheries grounds. The area off San Pedro is the most extensively fished of all areas.

Figure II-102 shows the bluefin tuna fishing areas during 1968 (Pinkas, 1971) and Figure II-103 indicates the three year, 1961-1965, total landings for jack mackerels (Blunt, 1969). Both species are primarily harvested by purse seines (Table II-103 App. 10, G.5), but the more near shore-shallow water landings of the jack mackerel are contrasted with the more seaward distribution of bluefin tunas. Figure II-104 shows the relative landing intensity of the Northern anchovy during 1967-1968 (Messersmith, 1969).

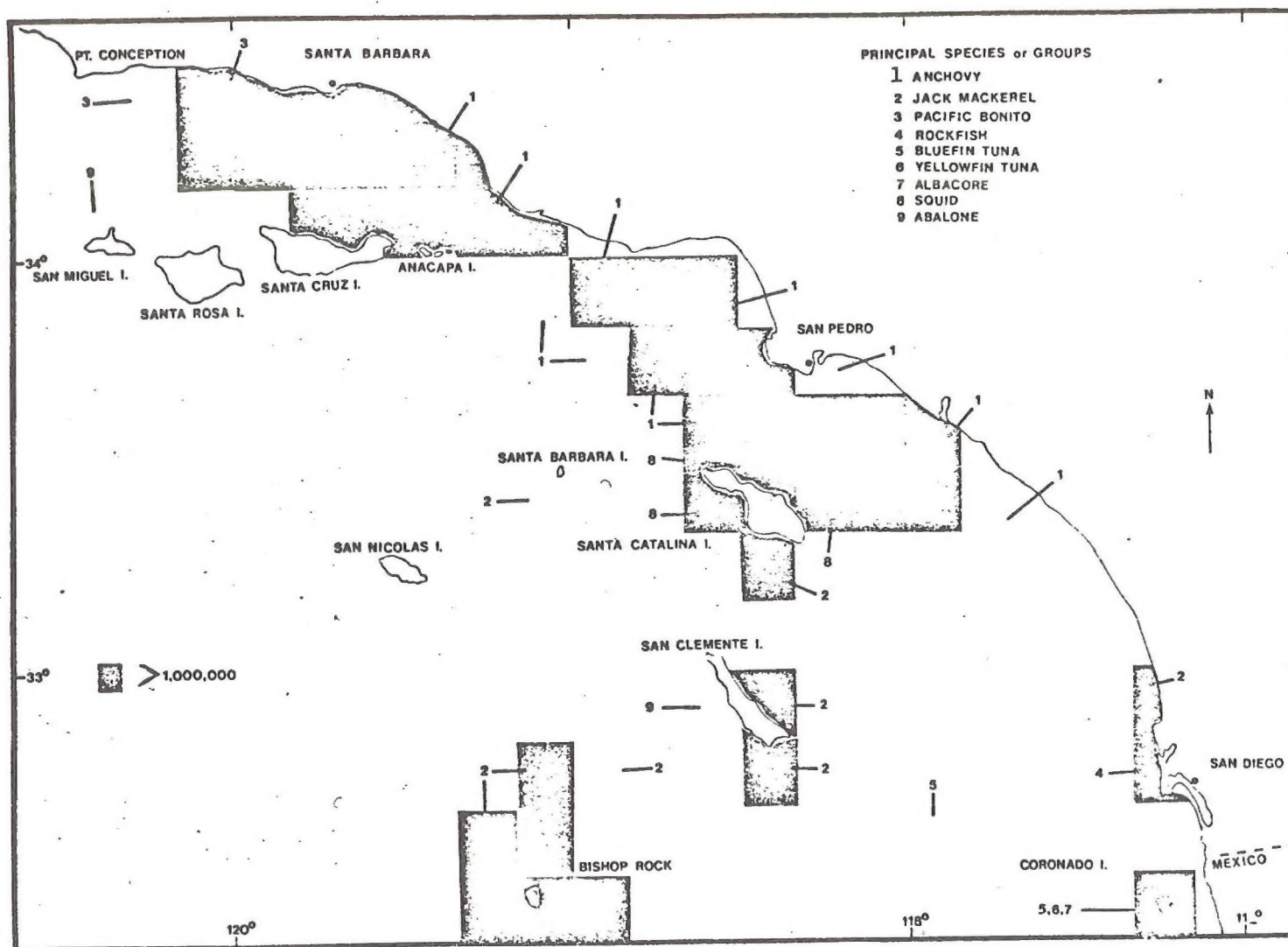


Figure II-101 Areas of concentration of commercial fish landings in Southern California waters for 1972. Principal species are referred to by number. (from Report 1-AA, unpublished catch by origin and species, compiled by the Marine Fisheries Statistics Staff, Calif. Fish and Game).

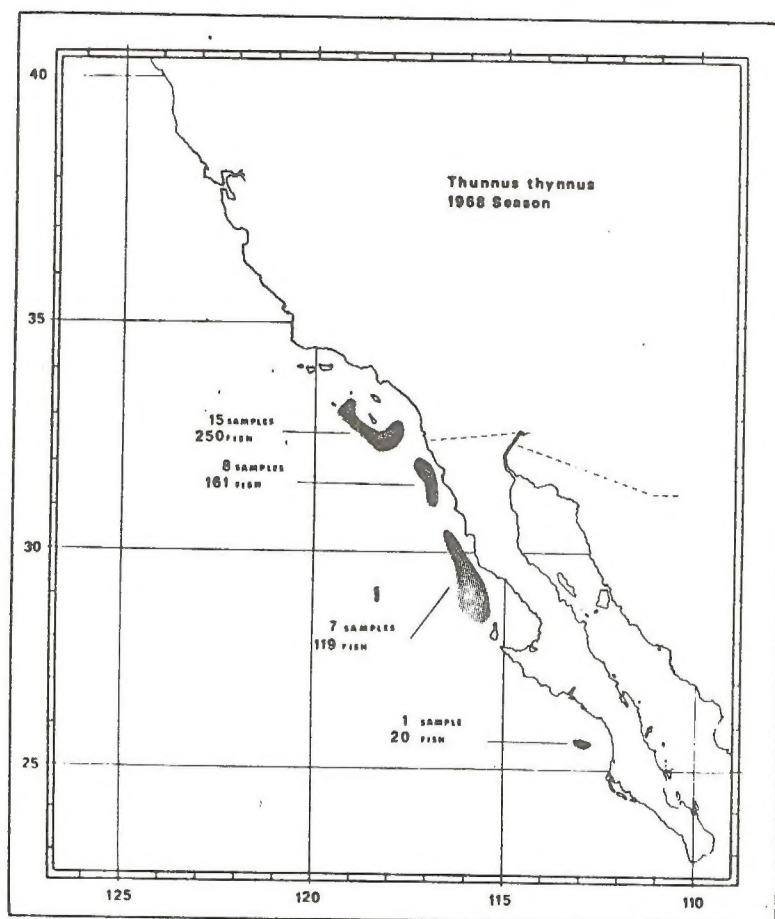


Figure II -102 Number and general catch localities of bluefin tuna collected in 1968. From: Pinkas (1971)

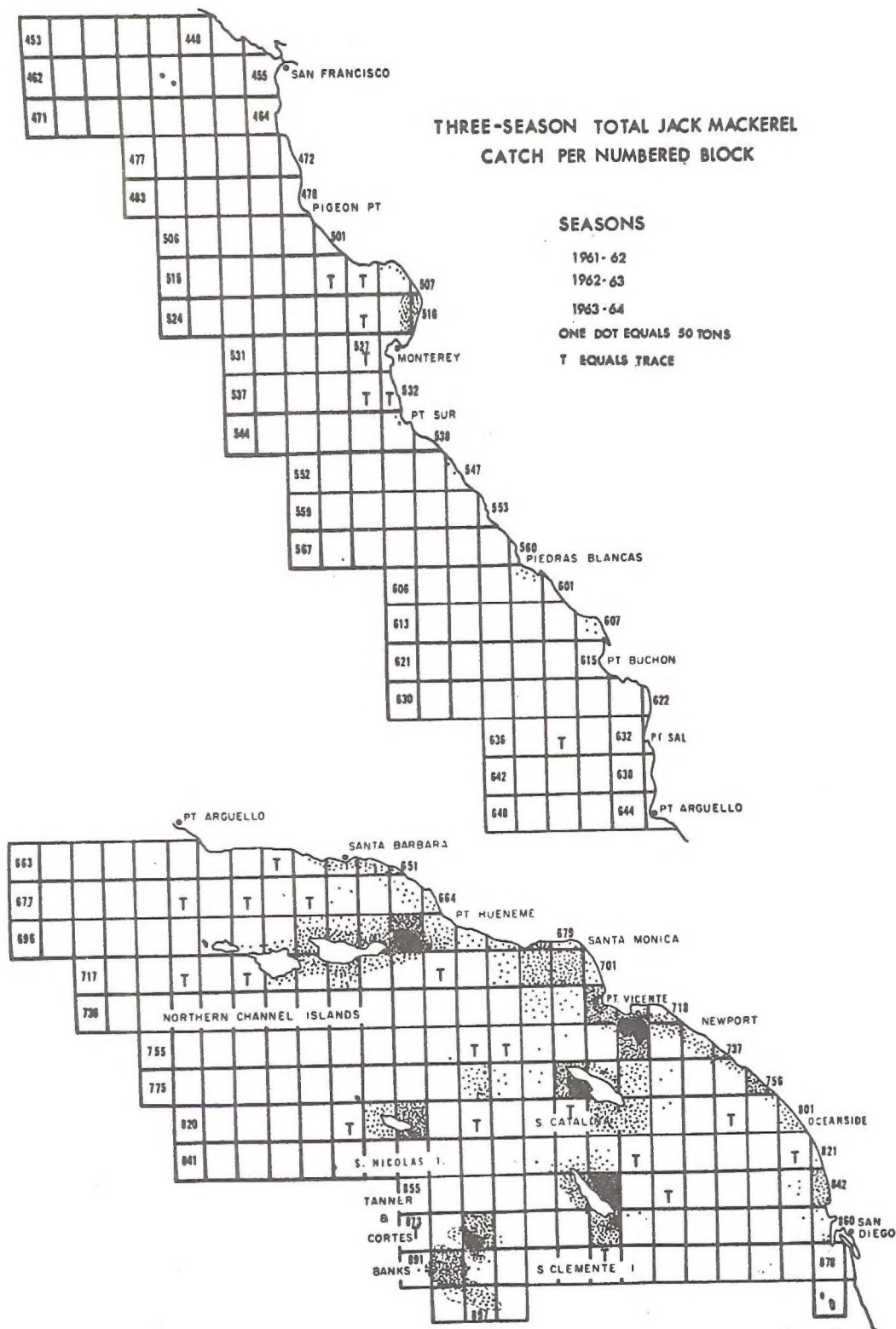


Figure II-103 Three-season total jack mackerel catch per numbered block; seasons 1961-62, 1962-63, and 1963-64 (Duffy, 1968). The total catch for these seasons was 145,167 tons. From: Blunt (1969)

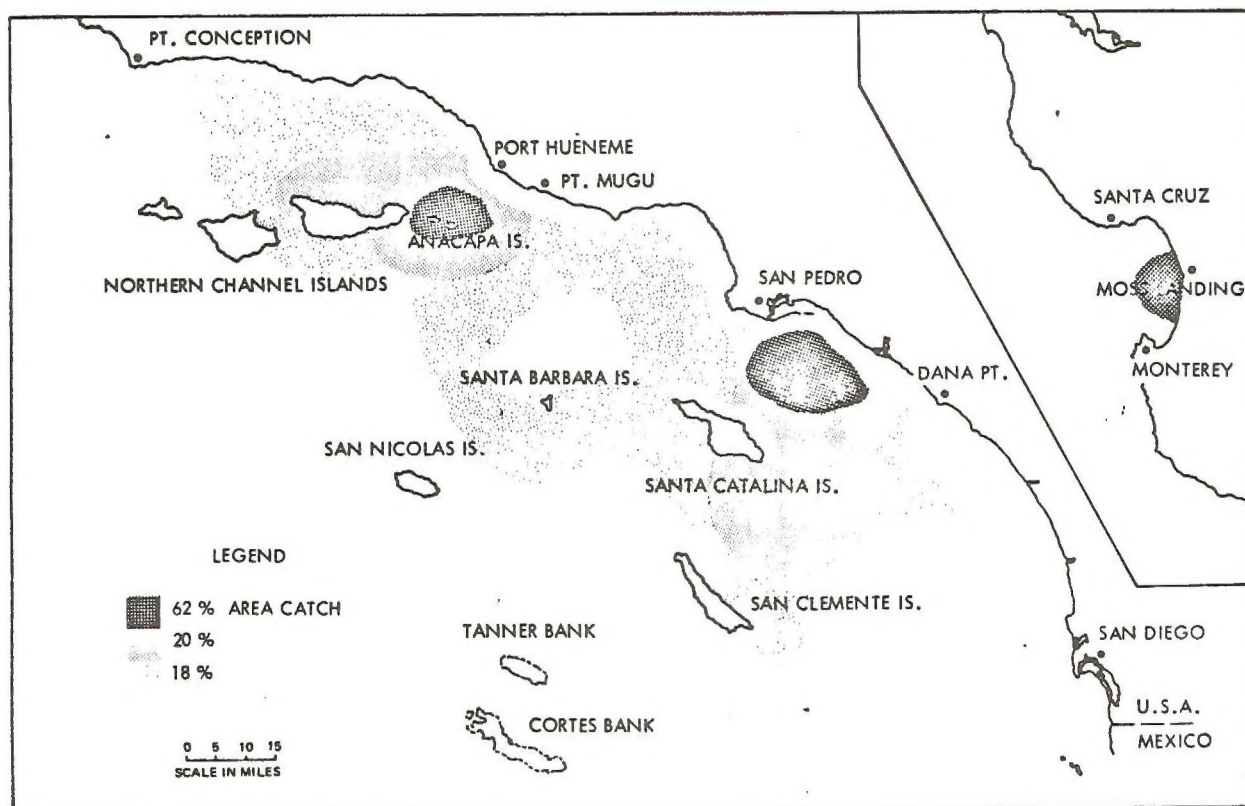


Figure II-104 Anchovy reduction fishing catch areas, 1 October 1966 through 30 April 1967.

From: Messersmith (1969)

d. Fishing Vessels

The trend in the number of registered commercial fishing vessels in California since 1960 has been upward (Frey, 1971). This trend is continuing and the number of commercial fishing vessels has increased from fewer than 4,000 in 1965 to over 5,900 in the 1973/74 season. There were 11,524 individuals holding commercial fishing licenses in 1973/74. However, this statistic is misleading, since, in 1966 for example, only 73% of the registered vessels landed fish (Figure II-114a), and only 22% of them landed more than ten tons of fish. Frey (1971) listed three possible reasons for why there are so many registered vessels which do not sell fish or sell limited quantities of them: 1) by buying a commercial fishing license and registering the boat as a commercial vessel, a sportsman no longer is subject to sport catch limits; 2) a commercial fisherman is eligible for a number of tax advantages; and 3) a number of fishermen only fish commercially during the summer and spend the winter months engaged in other occupations.

There are many different types of California-based fishing fleets, but two of them, the tuna fleet and the San Pedro wetfish fleet, tend to represent extremes of the fishing industry with respect to both financial and physical conditions (Frey, 1971). The tuna fishery has been lucrative to industry and employees, whereas the wetfish industry has been extremely marginal. Perrin and Noetzel (1970) found that the San Pedro wetfish fleet had dwindled to half its size in ten years and that the fleet was antiquated, corporate profits and net worth low, working capital inadequate, crew earnings very low and not increasing in pace with inflation, and that employment in the fleet had decreased by 30%

in five years. A dilemma exists in that underused stocks of wetfish (jack mackerel and anchovies) exist in the Southern California region, but if they are to be harvested, the fleet must expand through the construction of new vessels or the acquisition of surplus vessels from other fisheries. The reverse situation is in effect in the tuna fleet. Based on data from a study by Green and Broadhead (1964), the price per pound of tuna was more than four times that of wetfish (the figure was closer to ten times higher in early 1974 based on anchovies at \$50 to \$60/ton and tuna at \$575/ton. In addition, earnings of tuna crewmen were about twice that of crewmen on wetfish boats. While the wetfish fleet is outmoded, the tuna fleet has been building new boats continually. The capacity is greater and the catch-effort relationship is better for the new vessels. The fact that \$5 million boats are being built testifies to the profitability of the tuna fishing industry (Frey, 1971). Of the various other types of fishing fleets between the above two extremes, many are marginal and some are lucrative. For most fisheries, not enough margin exists at the fisherman's end to entice necessary revenues, and the situation will invariably deteriorate unless steps are taken to improve the fishermen's position (Frey, 1971).

e. Processing Plants

In 1974 there were 13 canning and reduction plants and 17 curing and manufacturing plants operating in Southern California (Bell, personal communication, 1975). Fishes are canned, smoked and kippered, salted and bait cured or reduced to fish meal and fish oil. Tunas are the principal cannery fishes and most are canned in the Los Angeles district. Anchovies are the main fishes processed for meal and

oil in the reduction plants. In 1972, 94% of the anchovy catch was reduced (Bell, 1974).

The following canning and reduction plants were operating in Southern California in 1974: 1) Kal Kan Food, Inc., Vernon; 2) Lewis Foods, Long Beach; 3 and 4) Pan Pacific Fisheries, Inc. (two plants), Terminal Island; 5) Perk Foods Co., Inc., Los Angeles; 6) The Quaker Oats Co., Wilmington; 7) San Diego Stakes Welfare Cannery, San Diego; 8 and 9) Star Kist Foods, Inc. (two plants), Terminal Island; 10) Universal Packers Corporation, Oxnard; 11 and 12) Van Camp Sea Food Co. (two plants), Terminal Island; and 13) Wertgate-California Food, Inc., San Diego. The seventeen plants curing and manufacturing fishery products were: 1) Bob's Old Fashion Smoked Fish, Newport Beach; 2) City of Oceanside Fish Market, Oceanside; 3) Crab Shell Fish Market and Cafe, Venice; 4) Dinkey Fish Market, Torrance; 5) The Fisherman's Outlet Corp., Los Angeles; 6) Gugie's Lobster Pot, San Pedro; 7) Harbor Fish Market, Oceanside; 8) Los Angeles Smoking and Curing Co., Los Angeles; 9) Norms Landing Fish Marketing, San Pedro; 10) Pacific Fish and Seafoods, Inc., Costa Mesa; 11) Pacific Smoke Curing, Inc., Solano Beach; 12) Point Loma Seafoods, San Diego; 13) Seven Seas Fish Co., Los Angeles; 14) Smoke House, Santa Barbara; 15) The Smokehouse, Santa Ana; 16) Three Star Smoked Fish Co., Inc., Los Angeles; and 17) Van's Smoking and Curing, Lynwood.

f. Shellfish

Shellfish include molluscans, such as clams, oysters, snails and abalone, and crustaceans, such as shrimp, prawns, lobsters, and crabs. Some shellfish have been mentioned in connection with inter-

tidal and bottom (benthic) animals. Others are drifting animals or zooplankton. The majority of shellfish spend the early part of their lives as zooplankton. The geographic distribution, habitat distribution, spawning and setting peaks, generalized diet, and abundance in Southern California of most of the larger important species are shown on Table G5-4 Appendix 10 G.5 (Frey, 1971).

The majority of shellfish species have limited spawning throughout the year, but have important periods when spawning peaks. The "relatively abundant" heading on Table G5-4 is very subjective. A single X usually means a species is equal to or more abundant off Southern California than it is in other parts of the state. A double X indicates that a species is a dominant organism of the area. This is particularly subjective and information is not always sufficient.

Several species require information beyond that included on Table G5-4 (see Appendix).

Spiny Lobster

An important commercial fishery has been based on the California spiny lobster *Panulirus interruptus* for more than seventy years. These tasty crustaceans are caught commercially with box like traps, built from wire, wood or plastic. Traps are normally placed in less than 60 feet of water, but sometimes in over 200 foot depths. Sport divers are only allowed to use their hands or hoop nets to capture lobsters.

Panulirus interruptus occurs between Monterey Bay, California and Magdalena Bay, Baja California and in the northern portions of the Gulf of California. Lobsters grow very slowly and it takes approximately ten years for females and 11 years for males to reach the legal size of 3.25

inches, carpace length (Frey, 1971). Most studies have shown that lobsters do not migrate or range over large distances.

Lobster landings have been declining since the early 50's, despite increased fishing and consumer demand. From 1936 through 1951 lobster landings averaged 1,294,209 pounds. Between 1968 and 1973 (most recent figures) landings decreased 78% to only 283,922 pounds (Bell, unpublished data). Large numbers of "shorts" are regularly taken by both commercial fishermen and sportsmen. The tremendous fishing pressure, the capture of many immatures ("shorts") and the slow growth rate coupled with relatively small individual ranges are probably the reasons for the decline in lobster production.

Abalone

Marine snails of the genus *Haliotis* have been an important food source in California since prehistoric times. Eight species are found in California; four of these *Haliotis rufescens* (red), *H. corrugata* (pink), *H. sorenseni* (white) and *H. fulgens* (green) make up most of the commercial and sport catch. Abalones spawn between late spring and through the fall. The larvae are free swimming for about two weeks and then settle to the bottom. They attach to rocks and begin grazing on small forms of algae. As adults, abalone feed on larger algae, such as *Macrocystis* sp. It takes five to eight years for abalone to reach commercial size.

Abalone production began a marked decline in 1967 (Frey, 1971). From 1957 through 1962 landings averaged 4,535,000 pounds. Landings from 1968 through 1973 averaged 3,377,522 pounds, a 26% reduction. This decline is continuing even though the consumer demand and fishing effort

have increased. As with lobsters, the decline is due, to a considerable extent, to the fact that both sport and commercial divers often exceed legal catch limits. Coupled with this is the marked decline in water quality (sewage, heated water discharges and so on) in many rocky coastal areas that once supported large abalone populations.

Other Shellfish

As mentioned above, shellfish fisheries in California have existed since prehistoric times. Many species contribute to this fishery. Important molluscs beside the abalone include the pismo, razor, gaper, and Washington clams and oysters. Important crustaceans, in addition to lobsters, include rock crabs (three species), bay and brine shrimp, and sand crabs. Molluscs contribute over \$1.8 million and crustaceans \$2.2 to \$4.1 million annually to the California commercial fishery. Rock crabs have become an important component in recent years. Their landings, by weight and value, during 1971 and 1972 are shown, by area, in Table G5-6 (Appendix 10 G.5). Lobster and abalone landings are also included in this table.

Many of the shellfish are dependent upon estuaries and bays. These areas have greatly reduced in size since 1900 when, according to the U. S. Fish and Wildlife Service (1972), there were 28 sizeable extuaries between Morro Bay, California and Ensenada, Mexico. Three have been destroyed, ten have been altered drastically and 15 have been modified slightly or moderately. There has been a 75% reduction of coastal wet-

land and estuarine acreage since the beginning of the century. The existence of many organisms is being threatened as a result. Estuaries are discussed further in Section II.F.1.

Inshore bait landings (primarily shellfish) from bays, rivers, and intertidal regions are presented on Table G5-7 (Appendix 10, G.5). These data partly reflect species distribution (brine and bay shrimp), but probably primarily reflect the heavy demand for sportfish bait in the heavily populated areas of Los Angeles and San Diego. Seven shellfish species were landed exclusively in the Los Angeles or San Diego areas. Although the statewide income from inshore bait landings is only about \$500,000, the nearly 1.25 million pounds landed during 1972 represents a significant number of organisms according to Oliphant (1973). A dozen sand crabs, for example, equals only 0.041 lbs. Conversions used for obtaining the landing weights are shown on Table G5-8 (Appendix 10, G.5).

g. Kelp and Algae Resources

Unless otherwise stated, information for the kelp and algae resources was taken from Murray (1974).

A number of Southern California seaweeds including the large kelp, *Macrocystis*, are of economic value. However, costs of collection and processing have reduced considerably the utilization of most species. Many red algae, for example, are of commercial value for the extraction of agar and carrageenin. Costs of collection of these algae by

hand, a virtual necessity due to the presence of many other unvalued species growing side-by-side desired, has made labor costs in the U.S. prohibitive. In Baja California, where labor costs are much reduced, valued red algae are collected on a wide scale; these are frequently shipped to San Diego for processing. The giant kelp *Macrocystis*, however, occurs in dense stands in Southern California and can be conveniently harvested by means of mechanical "mowing" ships; consequently, a large industry has developed. According to Frey (1971) giant kelp is harvested by specially built barges. These vary in size and some are capable of carrying up to 300 tons of wet kelp. Kelp is cut to a maximum depth of 4 feet (by regulation) below the water's surface, and is transferred by a conveyor belt into the open hold of the barge. It then is transported to a processing plant where it is transformed to a saleable product. Although a large number of useful constituents can be extracted from *Macrocystis*, the product of greatest demand is a polysaccharide which has been given the commercial name algin. Algin is used according to Kelco information (Kelco, 1961) as suspending, thickening, emulsifying, stabilizing, film-forming and water-holding agents in the ice cream, dairy, food, beverage, pharmaceutical, cosmetic, paint, rubber, ceramics, water treatment, insecticide spraying, welding, textile and paper and cardboard industries; it is manufactured

by the Kelco Co. of San Diego. Kelp is also used as a nutritional supplement for humans and animal foods (Philip R. Parke Co., San Pedro) and as a fertilizer (Kelp Organic Products Company, Los Angeles). Algin occurs in the cell walls of lammarian brown algae (kelps); the content of algin in Macrocystis pyrifera has been reported by several authors (Hoagland, 1915, Hoagland and Leib, 1915, Tressler, 1973) to be 13-24% of dry weight or 1.7 to 3.1% of wet weight (North, 1971). Kelp harvest records (Table II-100, App. 10, G.5) are available for almost a fifty year period (North, 1971). Prices and demand for kelp products have oscillated markedly over this period. Currently, prices for dried kelp have varied from approximately \$90-125/ton based on prices quoted by C.D. Pratt, Vice President, Kelco Company.

Figure II-105 shows the history of kelp harvest for California in wet tons per year through 1969. The harvest has been fairly steady since 1960 and has averaged 129,000 wet tons per year (Frey, 1971). The harvest from 1970 to 1972 is shown on Table G5-10 (App. 10, G.5) (Hester, 1974). According to the data presented by Hester, the total harvest of 115,559 tons in 1971 and 162,511 tons in 1972 may indicate a true increase in the kelp industry. Future years' harvest will be required to confirm this. Reference to kelp harvests and processing plants at individual ports are mentioned elsewhere in this section. Kelp beds and attached algae are discussed further in Sections III.E.3.a. and II.F.2.

A large number of red algal species have been utilized by man either directly as animal and human food or as a source for extracted materials. The latter is by far the most economically important.

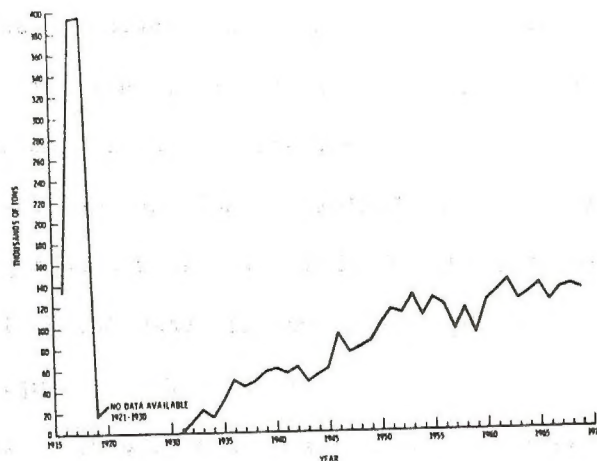


Figure II -105 California kelp harvest. From: Frey (1971)

Of the red algae employed as food, *Rhodymenia palmata*, and various species of *Porphyra* are probably the most important. These species are employed as food principally in western Europe and the Atlantic Coast of North America and most of the Orient; Japan is the most important producer and user of red algae as food.

Polysaccharide complexes are extracted from red and brown algae; these form colloidal suspensions when dispersed in water. For the Rhodophyta, two principal classes of polysaccharide exist, agar-polysaccharides and carrageenan polysaccharides.

Agar polysaccharides are used in the production of agar, probably the best known of all algal products. Agar is obtained (Dixon, 1973) commercially from species of *Gelidium* and *Pterocladia* as well as from various other algae, such as *Acanthopeltis*, *Ahnfeltia* and *Gracilaria*. Plants of *Gelidium robustum* harvested during summer provide the maximum yield of agar (Cooper and Johnstone, 1944). *Gelidium robustum* is a common component of the Southern California algal flora (App. Table E3-1). The bulk of agar is obtained today from Japan, Korea and Morocco. Smaller quantities are produced in Europe (France, Italy, Spain), Africa (Egypt, South Africa), Asia (Ceylon, India, Indonesia) and the Americas (California, Mexico, Brazil, Chile). Several surveys of the production and uses of agar have been published in recent years (Humm, 1951; Boney, 1965; Chapman, 1970). Some uses include: gelling, thickening purposes in canning of meats and fish; the manufacturing of processed cheese, mayonnaise, puddings, creams and jellies; pharmaceutical uses as a laxative, inert carrier of drug products, stabilizer for emulsions, and constituent of cosmetics, ointments and lo-

tions; and as a stiffening agent (agar) for microbial growth media.

Carrageenan is the extract of "carrageen" or "Irish Moss", the trade names for a mixture of *Chondrus crispus* and various species of *Gigartina*. The major production of carrageenan takes place in the United States (Atlantic Coast), Canada, France, Ireland and Norway where *Chondrus crispus* and *Gigartina stellata* are harvested and utilized. Species of *Phyllophora*, *Eucheuma* and *Furcellaria* are also employed in other portions of the world for carrageenan extraction. Carrageenans are used for many of the same purposes as agar although because of their lower gel strength, they are used less often for stiffening purposes than agar; carrageenans have been found to be superior to agar in stabilizing certain emulsions (e.g., paints, cosmetics, some pharmaceutical preparations) and for the stiffening of milk and dairy products.

Although economically important red algae, particularly *Gelidium robustum*, are abundant in Southern California, this resource has yet to be really tapped. At present, only one firm, American Agar and Chemical Company, San Diego, California is in operation (Silverthorne and Sorensen, 1971). This firm produces a high grade of bacteriological agar, using *Gelidium* collected primarily from Mexico. Approximately 160 metric tons per year, valued in 1971 at 2 million dollars, represented the production of American Agar and Chemical Company for 1970 (Silverthorne and Sorensen, 1971).

h. Mariculture

The history of mariculture in California is essentially that of the cultivation of two non-native species of oysters, the eastern oyster and the Pacific oyster (Ebert, 1973). Both of these have been cultivated only in areas north of Point Conception. California is currently in the midst of a research and development period for mariculture. Southern California is definitely in the infant stages of mariculture even compared with the rest of the state and especially compared with some other states and other countries.

At the present time in California, private enterprises, state and federal laboratories, and academic institutions have maricultural projects in progress. Ebert (1973) listed 17 private companies engaged in mariculture in California. Most are working with oysters, abalone, or lobster and are in various operational stages from research and development to full production. Only one of the 17 is located in Southern California, the Limnos Corporation located in San Diego Bay. This company is in the pilot production stage of cultivation of brown shrimp in a 100-acre pond receiving heated water effluent from a power plant.

In late 1970, a marine culture laboratory, operated by the California Department of Fish and Game, was opened in central California, south of Monterey at Granite Canyon. Priority species being investigated there include Pacific oyster, red abalone, and spot prawn.

The Southwest Fisheries Center of the National Marine Fisheries Service in La Jolla has in the last few years reared several species

of marine fishes from the egg through to metamorphosis in the laboratory. These species include northern anchovy, Pacific sardine, Pacific mackerel, and striped bass (Reuben Lasker, personal communication).

The National Sea Grant Program currently provides funding to six universities in California for mariculture-oriented projects (Ebert, 1973). Four of these institutions are in Southern California. California Institute of Technology has a project to restore, propagate, and manage giant kelp. The Institute of Marine Resources at the University of California, San Diego is involved in abalone culture methodology and larval ecology. The University of California, Santa Barbara, is continuing to study seaweed resource management. San Diego State University has one project underway on the recruitment and growth of spiny lobster, and one on the investigation and development of an American lobster fishery in California.

1. Recommendations for Utilization of Fisheries Resources

- Specific Recommendations

Frey (1971), based on data then available, formulated a plan by which the marine resources of California should be utilized. A summary of the plan is presented in Table G5-11 (App. 10, G.5). Northern California species are included so that the table provides a general picture for the entire state.

- General Recommendations

Frey (1971) also gave the following list of general recommendations for the California Department of Fish and Game that should be

considered relevant to all marine species along the coast of California: 1) Continue to monitor the commercial harvest; 2) Develop and implement plans and programs to estimate the total size of the annual sport harvest of California's living marine resources (at present only the size of the annual partyboat harvest is known); 3) Continue law enforcement activities to maintain adequate management programs; 4) Develop and implement plans and programs to obtain fishing effort data from all commercial fishing vessels registered in California; 5) Continue studies on designated fishes to determine the population structures, seasonal migrational movements, interrelationships, and other pertinent information needed to manage those living marine resources on a scientific basis; 6) When necessary, conduct special studies to answer specific questions concerning a species or group of species; 7) Develop and implement plans and programs to determine the effects of various pollutants, including pesticides, sewage, and thermal discharges, on the ocean environment and on the living marine resources; 8) Continue to work with Regional Water Quality Control Boards as well as the California State Water Resources Control Board to reduce or eliminate pollution in estuaries and nearshore areas; 9) Continue cooperating with the federal government in negotiations with Mexico and other nations with respect to the conservation and utilization of those living marine resources which are jointly harvested; 10) Continue to cooperate with the National Marine Fisheries Service, Pacific Marine Fisheries Commission, and the state governments of Washington and Oregon concerning the conservation and utilization of those living marine resources jointly harvested by citizens of Pacific Coast

states; 11) Encourage the National Marine Fisheries Service and industry to develop more effective fishing gear and fishing methods to improve the cost-benefit relationship of fishing operations by California citizens; 12) Encourage the fishing industry and Federal government to develop new methods of harvesting and markets for some of the underutilized or latent living marine resources along the California coast; 13) Work with the California Department of Education and academic institutions throughout the state to develop study programs and class curricula in such a manner as to minimize the collecting of marine life from intertidal areas; and 14) Continue research in developing shellfish culture methods as well as initiating work in cultivating other marine organisms and encourage the development of mariculture in California.

The interplay and conflicts between commercial fisheries and sport fisheries are discussed in Section II.G.3.

j. County by County Summary

The areas Santa Barbara, Los Angeles, and San Diego, referred to on Table G5-1 (App. 10, G.5) were designated by the Department of Fish and Game and are not necessarily delineated by county boundaries. The California Department of Fish and Game (1973) discussed the major commercial fishing ports by county. We will combine these counties into the fishery areas discussed above. Shellfisheries and kelp harvesting operations are also summarized in the following port descriptions.

Santa Barbara: This area consists of two counties, Santa Barbara and Ventura. In addition to the two major ports discussed below, landings are also reported from Oxnard and Ventura.

In Santa Barbara County, the only major port is located near the southeast corner of the county, 48 miles down the coast from Point Conception. Santa Barbara Harbor provides shelter for numerous commercial fishing boats and the unloading and processing facilities located here are excellent. Trawlers operating out of Santa Barbara land catches of rockfish, English sole, petrale sole, and other species of flatfish. Most of the flatfish are filleted and sold on the market as fresh fish while the rockfish are sold whole and filleted as fresh fish. Pacific bonito and other pelagic species are caught offshore each year by boats using purse seines. The bonito is shipped to the canning plants at Terminal Island and Oxnard. Lobster boats work the offshore waters with traps, while diving boats bring in catches of abalone. The lobsters and abalone are sold on the fresh fish market after being processed in local plants. The state's most extensive kelp bed is located between Point Conception and Santa Barbara, and commercial boats, representing companies based in San Pedro and Port Hueneme, harvest the kelp for processing. Many other miscellaneous species of fish landed are processed at the local plants for use as animal food. Figure II-68 of Section II.F.1. indicates that despite a slight decrease in landings from 1965 to 1969, the dollar value of the fisheries has increased by over \$100,000 a year.

Port Hueneme is located on the central Ventura County coast, 11 miles south of the city of Ventura. The harbor is protected from rough seas by two jetties at its mouth. Several purse seiners operate out of the port with anchovy, mackerel, bonito, squid, and other pelagic fish being the major species landed. Trawlers land their

catches of rockfish and flatfish at Port Hueneme, where lobster and abalone boats fishing the waters around the offshore islands also land their catches.

Most of the fish landed are either sold as fresh fish at the local markets or shipped to the Oxnard Cannery for processing. The Oxnard plant has facilities for canning squid, mackerel, and bonito, and for reducing anchovies and waste fish to fish meal and oil.

One kelp company, holding leases in Santa Barbara County and Ventura County waters, has a dock and processing facilities in the port. The company harvests giant kelp from both mainland and island beds. Figure II-69 of Section II.F.1. indicates a highly significant increase in both landings and dollar value of the commercial fisheries in Ventura County.

Los Angeles: This area consists of Los Angeles and Orange Counties. In addition to the ports discussed below, landings are reported from Wilmington and a few other small ports where spiny lobsters are the main resource reported.

Terminal Island is located south of Wilmington, west of Long Beach and east of San Pedro to form the Los Angeles-Long Beach inner harbor. Distant water tuna fleets, local purse seiners and market fish boats all base their operations here. The tuna fleets land catches of albacore, bluefin, skipjack, and yellowfin tuna for processing at the six canning plants located at Terminal Island. In addition to the approximately 250 million pounds of tuna landed locally in 1970, shipments totaling 90 million pounds were received from other ports for processing at the Terminal Island plants. The

local purse seine fleet fishes the offshore waters for Pacific bonito, jack mackerel, anchovy, squid, and Pacific mackerel. The catch is canned at Terminal Island and in other area processing plants. Market fish boats dock at Terminal Island, but their catches are at other receiving ports.

San Pedro is located at the west end of San Pedro Bay about 23 miles south of downtown Los Angeles and about one mile across the channel from Terminal Island. Numerous purse seiners, a tuna fleet and a market boat fleet are based at San Pedro. The local purse seine fleet fishes primarily for squid, Pacific bonito, jack mackerel, Pacific mackerel, anchovy and sardine. The catch is landed at San Pedro and Terminal Island canneries for processing. The tuna fleet lands catches of several species of tuna which are sold fresh on the San Pedro market or are landed at the nearby Terminal Island plants for canning.

Numerous boats use gear designed to catch various species of bottomfish, and land catches of rockfish, halibut, sea bass, croaker, blacksmith, halfmoon, opaleye, grouper, and several other species. These catches are then processed by the local fresh fish dealers for distribution in the Los Angeles area. In 1970, there were two plants curing and manufacturing fish products at San Pedro.

Long Beach and Santa Monica Bay Ports: These ports are of relatively minor importance as far as landings are concerned. The major species landed at these ports are spiny lobster, abalone, anchovy, rockfish, rock crab, and swordfish. These totalled approximately 420,000 pounds in 1970. The facilities located at these ports are of

significant importance, however, as they process fish shipped from numerous other ports.

Los Angeles Harbor area has four plants which cure or manufacture fishery products and one reduction plant that reduces anchovy to fish meal and fish oil. Long Beach and Wilmington each have one plant for curing and manufacturing fishery products and Wilmington also has one canning and reduction plant. Products that are produced at these plants include smoked tuna, smoked Pacific bonito, smoked halibut, and smoked swordfish; smoked and kippered salmon and sablefish; and fish meal and fish oil.

Some experimental mariculture work with Japanese prawns has been conducted in Los Angeles Harbor, but was discontinued because of water quality problems.

Los Angeles is the most populated county of California. Its ports are the first in the nation with respect to value of commercial fish landings. It should be remembered when examining Figures II-68 through II-72 of Section II.F.1. that these data include yellowfin and skipjack tuna (not landed in California waters). Figure II-70 of Section II.F.1. indicates that landings and dollar value were constant from 1965 through 1968, but increased significantly in 1969.

Newport Beach is located six miles southeast of Huntington Beach on a sandspit between the ocean and Newport Bay. The bay provides shelter for a variety of commercial fishing boats, including trollers, trawlers, purse seiners, and gill netters. These commercial boats fish the offshore waters and land catches of albacore, California halibut, white sea bass, mackerel, lobster, abalone, and swordfish. A

dory fishery and market, based at the Newport Beach Pier, is unique to this port. Dory setliners, who launch their boats through the surf, fish off Newport the year round, and then sell them directly to the public from their dories.

In 1970, Newport Beach and Seal Beach each had one plant curing and manufacturing fishery products. The major products processed at these plants include smoked swordfish, smoked halibut and smoked albacore. The white sea bass, spiny lobster, abalone, and halibut landed at this port are sold on the fresh fish market.

A commercial fishing industry exists for the small inshore bait species utilized by the sport angler. As the inshore tidal areas become more urbanized, this bait, essential for catching some sport species, will become less abundant. Figure II-71 of Section II.F.1. indicates that landings are erratic and inconsistent, but the relative value per pound of fish landed tends to be increasing.

San Diego: In addition to the port of San Diego, Oceanside and several small ports also report landings.

San Diego harbor is our most southerly port and is second only to San Pedro in importance as a tuna processing center. A large proportion of the state's high seas tuna and market fish fleet is based in this port. The majority of the San Diego fleet is composed of high seas tuna purse seiners and live bait boats. The domestic fleet is composed primarily of multi-purpose vessels rigged for abalone, spiny lobster trap fishing, and gill netting. Many of the local vessels are light high-speed boats designed to fish only the inshore areas. Many of this latter type of craft are transported on trailers and are

designed to be launched in the surf.

San Diego County contains some of the largest kelp beds in the state and is the state's leading producer of kelp and kelp products. The only agar processing industry in California is also located in San Diego, but since World War II, it has relied almost exclusively on imported raw material because of high local harvesting costs. Recently, however, the local agar harvesting industry shows signs of being renewed as high world market prices and a scarcity of raw agar may once again allow local harvesting to be competitive. The port, in addition to fish canneries, also has facilities for processing abalone, fresh fish, and spiny lobsters for local and northern population centers.

In recent years there has been an increased interest in mariculture. The warm climate and waters of San Diego County provide some of the essentials necessary for competitive mariculture operations; however, the high cost of land limits the local potential. Experimental mariculture studies are presently being conducted in conjunction with the power plant and salt ponds in South San Diego Bay, and at the power plant outfall in Aqua Hedionda Lagoon at Carlsbad. At this time, however, these operations are not on a commercial scale.

Many commercial fishing boats are based at the port of San Diego. In past years, considerable quantities of tuna were canned at this port; however, this has decreased and much of the tuna landed at San Diego is trucked to canneries in the Los Angeles Harbor area. Sizeable quantities of fresh fish are also landed at this port.

The landings and dollar value of San Diego County are shown on Figure II-72 of Section II.F.1.

k. Mexican and Foreign Fisheries

Hester (1974) summarized foreign fisheries and Mexican fisheries off Baja, California.

With the exception of the Mexican fisheries the only significant amount of foreign activity in the area is tuna fishing by oriental long liners off Baja which take several thousand tons of swordfish and striped marlin annually. Soviet trawlers do on occasion enter the area, but full-scale fishing is conducted further north. The Soviets may attempt to develop an anchovy fishery off California. The hake resource, which winters and spawns in the area, is exploited by the Soviets during its summer northward migration to Oregon and Washington. Exploratory cruises have been made by the Soviets into the area for rockfish, anchovy and red crab, but no fishery has developed. Japanese explorations for saury took place off Monterey, again no fishery developed.

The Mexican fisheries off the west coast of Baja are in the process of developing. The Mexican fish canning industry is centered here, and in addition, the coast provides fresh and frozen fish, lobster and abalone and some tonnage of kelp.

For two reasons it is impossible to provide good statistics for the area. Mexico's fisheries have undergone nationalization and the research organizations have not yet settled down. In a few months, that is by mid-1974, statistics for the area are supposed to be available, but they will be based on cannery records which are often

difficult to interpret.

Second, the canneries are located on the Pacific, but much of the raw material is trucked across the peninsula from the Gulf of California. These catches cannot be separated from catches made in the Pacific.

At present there are about 13 canneries in Baja. With two exceptions all of the seafood canned in Baja is sold in Mexico. Included are canned tuna, sardines, anchovies (labeled sardine mostly), jack and Pacific mackerel, bonito, squid and mussels. All the fish meal produced are sold in Mexico. The exceptions are canned abalone, about half of which is exported to the U.S. or Asia, and pet food made from tuna scrap, which is exported to the U.S.

The value of processed fishing products to Baja was \$9,057,000 in 1965 and \$10,519,000 in 1966, the two years for which data are available (Crocker, 1968). These figures are probably still close to the value in 1971 with some increase owing to the tuna pack at Cape San Lucas.

The greatest potential fishery off Baja is the anchovy. With rising prices and demand for fishmeal, it is likely that a major reduction fishery will develop shortly. Zapata and International Protein, two large fishmeal producers, are reportedly negotiating with the Mexican Government for fishing rights. Fishmeal operations in Mexico are subject to less stringent regulations than they are in California.

Until the reduction fishery does develop, the mainstay of the industry are canned tuna, bonito, and wetfish. The latter are sardine,

anchovy, jack and Pacific mackerel. Pacific mackerel stocks have declined as they did off California. Sardine are still present off Baja, but large stocks were found in the Gulf in the late 60's and a major portion of the boats moved around to fish there. The sardines were trucked to the canneries from the Gulf and cannot be separated from Pacific landings. Anchovy and jack mackerel landings, however, can be obtained (Table G5-12, App. 10, G.5). The decline beginning in 1968 is owing to the shift in effort to the Gulf.

6. Oil and Gas Resources

During 1973 there was an average of 178 wells offshore California in federal waters which produced 18.78 million barrels of oil from five fixed platforms, plus 9.16 million Mcf of gas. All of these platforms were within the Dos Cuadras and Carpinteria areas offshore from Santa Barbara County.

Oil and gas production from the state tidelands areas totalled 70.48 million barrels and 30.6 million Mcf of gas (associated and non-associated) during 1973. Table II-72 reflects California offshore production statistics for 1973:

Table II-72

PRODUCTION STATISTICS OF CALIFORNIA OFFSHORE FIELDS-1973

		Average number of producing wells	
Oil field or area		Oil (bbl.)	Gas (Mcf)
State			
Alegria-----	1	42,428	163,877
Belmont-----	77	2,217,722	367,213
Carpinteria-----	58	1,605,028	2,476,623
Coal Oil Point-----	2	28,535	60,808
Conception-----	3	38,953	18,365
Cuarta-----	0	0	0
Elwood, offshore area-----	12	58,895	395,349
Elwood, South-----	10	1,176,111	66,495
Huntington Beach, offshore area--	332	16,050,382	2,286,543
Montalvo, West, offshore area----	6	97,986	0
Newport, West, offshore area-----	15	118,243	37,156
Point Conception, offshore area--	2	123,700	44,506
Rincon, offshore area-----	80	586,567	310,398
Summerland-----	21	259,957	1,662,610
Torrance, offshore area-----	22	404,273	335,196
Venice Beach, offshore area-----	4	145,393	58,868
Wilmington, offshore area-----	948	47,526,287	12,637,812
Totals-----	1,593	70,480,460	20,921,819
Federal			
Carpinteria-----	49	2,189,947	1,473,994
Dos Cuadras-----	129	16,590,524	7,684,483
Totals-----	178	18,780,471	9,158,477
Grand totals-----	1,771	89,260,931	30,080,296

Source: State of California Division of Oil and Gas.

California's offshore production facilities are physically located from the Santa Barbara Channel south to Orange County. Each of the fields (above) are located offshore from this four-county area.

The following figures show total oil and gas production from both the onshore and offshore California fields:

Production from California Fields - State and Federal
(millions of bbl. and millions Mcf)

	<u>1973</u>		<u>1972</u>	
	<u>oil</u>	<u>gas*</u>	<u>oil</u>	<u>gas*</u>
State				
onshore	246.9	473.8	251.4	508.1
offshore	70.5	30.6	73.0	34.8
Federal				
offshore	18.8	9.2	22.6	12.5
Totals	336.2	513.6	347.0	555.4

*"gas" here includes both associated and non-associated (wet and dry) gas.
Source: State of California Division of Oil and Gas.

As reflected in the above statistics, petroleum production declined 2.2% compared to 1972 within state areas, while production from the federal OCS declined 16.8%. Net gas withdrawn during 1973 from state areas declined 7.1%, and from the federal OCS it declined 26.4%.

Table II-73 reflects the 1973 production and value of production of oil and gas from the four coastal counties (excluding federal OCS):

Table II-73

Production of Oil, Gas, and
Value of Oil and Gas by Counties - 1973

County	Oil		Gas (Mcf.)			
	Production (bbl.)	\$ Value (thousands)	From oil zones	From dry gas zones	Total	\$ Value (thousands)
Los Angeles----	98,486,441	337,798.8	56,346,828	360,766	56,707,594	20,669.4
Orange-----	36,262,155	126,954.5	9,988,932	0	9,988,932	3,599.3
Santa Barbara--	19,133,622	57,314.2	21,868,949	24,558,858	46,427,807	17,800.3
Ventura-----	23,593,327	84,959.1	25,565,781	1,589,224	27,155,005	10,280.1
Total-----	317,347,170	1,040,889.9	212,444,470	291,983,607	504,428,077	187,018.8

Source: State of California Division of Oil and Gas.

As the preceding table reflects, the four Southern California coastal counties accounted for 56% of the entire state's production of oil, 58% of its gas, and approximately 28% of the total value of each of them.

The following lists the twenty-five largest oil producing companies in California during 1973, and their individual total yearly production.

25 Largest California Oil Producers in 1973

Producer	Oil production (bbl)
1. Standard Oil Co. of Calif.	43,565,355
2. Thums Long Beach Co.	40,759,842
3. Getty Oil Co.	36,182,012
4. Shell Oil Co.	29,013,374
5. Mobil Oil Corp.	20,984,323
6. Union Oil Co. of Calif.	20,881,478
7. Signal Oil & Gas Co.	16,727,599
8. Texaco, Inc.	13,104,665
9. Chanslor-Western Oil & Development Co.	9,398,728
10. Champlin Petroleum Co.	8,797,199
11. Atlantic Richfield Co.	6,895,629
12. Continental Oil Co.	5,815,308
13. Belridge Oil Co.	5,410,209
14. Long Beach Oil Development Corp.	4,810,892
15. Atlantic Richfield Co., Opr.	4,805,863
16. Occidental Petroleum Corp.	4,032,905
17. Tenneco Oil Co.	3,998,383
18. Exxon Corp.	3,382,565
19. Gulf Oil Corp.	3,065,236
20. Sun Oil Co.	2,782,295
21. Powerine Oil Co.	2,197,857
22. Argo Petroleum Corp.	1,667,912
23. M. H. Whittier Corp.	1,514,099
24. General Crude Oil Co., Opr.	1,457,546
25. McCulloch Oil Corp.	1,297,831

Source: State of California Department of Conservation.

Thus, the ten largest oil producers had a total 1973 production in excess of 72% of all petroleum produced from state areas.

As noted by the State of California Division of Oil and Gas;

On December 11, 1973, the State Lands Commission partially lifted its drilling moratorium which was in effect nearly 5 years, to allow drilling from existing offshore facilities on a lease by lease basis.

While offshore oil production from state tideland fields continued to decline through 1973, offshore production did account for 22% of all California production.

Federal OCS production declined for the second consecutive year.

Although 120 oil spills were reported on land during 1973, the number of offshore spills continued to decline substantially (10 in 1973), all of which were minor and from non-drilling and non-producing sources.

For a more detailed account of all statistics discussed within this section, the reader is referred to the 1973 edition of Summary of Operations, issued in 1974 by the State of California Division of Oil and Gas.

H. Environmental Problems

1. Air Quality

a. Air Basins

With the passage of the Mulford-Carrell Air Resources Act of 1967 the state of California was directed to divide the State into air basins and to adopt appropriate ambient air quality standards. In compliance with that directive, the Air Resources Board on November 20, 1968 established eleven air basins within the State, and added two additional air basins in 1973. Impacts of this section may be found in Section III. F. 1.

By definition, the air basins were to be composed of areas having similar meteorological and geographical conditions. Consideration was also given to the existing political boundaries where ever practicable. Unlike watersheds, it is not possible to define air basins when the air pollution problems would be completely isolated from adjacent air basins. The criteria used in establishing the air basins, also used in creating the air basins within the study area are:

1. The basins should approximate the climatic zones and should separate, as far as practicable, the air pollution problems of one zone from those of another.
2. Because the law requires that all of the State be divided into basins, basins cannot be restricted to the low elevation areas but must include the adjacent mountain climatic zones.
3. Basin boundaries must be clearly specified so as to be readily identified for political purposes.
4. Basin boundaries need not be restricted to the crests of mountain ranges. As long as the boundary is located within the zone, the principle of separating the air pollution problems of one basin from the next must be maintained.
5. Where the mountain zones separating the basins do not include boundaries, prominent topographical features related

to the mountain zones determine the basin boundaries. As a result, some counties are divided into more than one basin.

6. The basins must be large enough to permit organization of regional air pollution control agencies.

Where the air basins do not adhere to county lines it is still necessary, for administrative purposes, that the boundaries be clearly definable and readily located lines. Examples include township, section lines, land grant boundaries, national parks, and Indian Reservations.

b. Study Basins

There are two air basins located within the study area. The two comprise the most southerly basins which extend south of Point Conception to the Mexican Border.

The South Coast Basin is made up of all of Ventura and Orange Counties, and portions of Los Angeles, Santa Barbara, San Bernardino, and Riverside Counties. The Channel Islands are included within the South Coast Basin.

The San Diego Basin contains all of San Diego county west of the peninsula range of mountains. The range of hills reaching the coast at the Orange-San Diego County line marks the approximate position of the shift in wind patterns separating the two air basins.

c. Air Pollution Control Districts

The enforcement and administrative processes of an air pollution control program are performed on a county wide basis by an Air Pollution Control District. There are seven control districts located within the study area, being part of the county health department and answerable to the legislative body of the county.

In general, activities of the air pollution control districts are coordinated and directed by the Air Pollution Control Officer who is appointed by the Air Pollution Control Board. The functions of such a district usually includes the following areas of consideration:

1. Enforcement
2. Engineering
3. Technical Services
4. Evaluation and Planning
5. Special Services
6. Administrative Services

The functions of the above groups vary in duty and function, but perform as a cohesive unit towards the ultimate goal of restoring and maintaining acceptable air quality.

d. Air Quality

In order to achieve an ambient level of air quality, standards were adopted for California. The data in the following table indicated those levels for California as well as those for the United States. (Table II-74).

The list of measured pollutants generally are divided into six major categories. These include oxides of nitrogen (NOX), hydrocarbons (HC), carbon monoxide (CO), sulfur dioxide (SO₂), oxidant, and particulate matter. A brief description of each category is as follows:

Oxides of Nitrogen (NOX)

Nitric Oxide results from the fixation of nitrogen and oxygen at high temperatures as found in fuel combustion. There are several atmospheric reactions which lead to the oxidation of nitric oxide to nitrogen dioxide, and the presence of nitrogen dioxide in ambient air is essential

Table II-74

Ambient Air Quality Standards
Applicable in California

Pollutant	Averaging Time	California Standards Concentration	Federal Standards	
			Primary	Secondary
Photochemical Oxidants (Corrected for NO ₂)	1 Hour	0.10ppm	0.08ppm	Same as Primary Standard
Carbon Monoxide	12 Hours	10ppm	-	Same as Primary Standard
	8 Hours	-	9 ppm	
	1 Hour	40ppm	30 ppm	
Nitrogen Dioxide	Annual Average	-	0.05ppm	Same as Primary Standard
	1 Hour	0.25ppm	-	
Sulphur Dioxide	Annual Average	-	0.03ppm	0.2ppm
	24 Hours	0.04ppm	0.14ppm	0.10ppm
	3 Hours	-	-	0.5ppm
	1 Hour	0.5ppm	-	-
Suspended Particulate Matter	Annual Geometric Mean	60	75	60
	24 Hours	100	260	150
Lead (Particulate)	30 Day Average	1.5	-	-
Hydrogen Sulfide	1 Hour	0.03ppm	-	-
Hydrocarbons (Corrected for Methane)	3 Hours	-	0.24ppm	Same as Primary Standard
Visibility Reducing Particles	1 Observation	Visibility to less than 10 miles when the relative humidity is less than 70 percent	-	-

Source: State of California Resources Agency-Air Resources Board. Air Pollution in California, Annual Report 1972, pg.4.

to the production of photochemical oxidants. The presence of nitrogen dioxide in ambient air has been associated with a variety of respiratory diseases.

Hydrocarbons (HC)

Defined as organic compounds composed exclusively of carbon and hydrogen, hydrocarbons are primarily associated with the use of petroleum products. Reactive hydrocarbons (RHC) are those that react in the atmosphere along with nitrogen oxides to produce photochemical smog. Oxygenated hydrocarbons, such as formaldehyde and other carbonyl compounds, help to initiate and accelerate formation of photochemicals in pollution. Hydrocarbons alone have no known effect on human health. Therefore, the sole purpose of prescribing a hydrocarbon standard is to control photochemical oxidants.

Carbon Monoxides (CO)

Carbon monoxide is the result of incomplete combustion of any compound containing carbon (coal, oil, gasoline, etc.) Carbon monoxide reacts with the hemoglobin in red blood cells to decrease the oxygen carrying capacity of the blood.

Sulfur Dioxide (SO₂)

The presence of sulfur oxides in the air has been associated with a variety of respiratory diseases and increased mortality rates. They represent a significant economic burden and have a nuisance impact. When sulfur oxides are inhaled with small particles, the health effect is increased. Inhalation of sulfur dioxide can cause increased airway resistance by constricting lung passages.

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Oxidants

Photochemical oxidants consist primarily of ozone and smaller amounts of PAN (peroxyacetylnitrate) and NO_2 . They are produced in the atmosphere by the reactions of all hydrocarbons in the presence of NO_x and sunlight, with methane, however, reacting sufficiently slowly to be considered "nonreactive". Photochemical oxidants cause irritation to the mucous membranes, damage to vegetation, and deterioration of materials. They affect the clearance mechanism of the lungs and alter resistance to respiratory bacterial infections. The national primary air quality standard for photochemical oxidants is based on evidence of increased frequency of asthma attacks when hourly averages reach 0.1 ppm. Eye irritation is possible when atmospheric concentrations reach the same level.

Particulate Matter

Small discrete masses of solid or liquid matter dispensed in the atmosphere, especially those of one micron or less in diameter, are associated with a variety of adverse effects on public health. Particulate matter in the respiratory tract may produce injury by itself, or it may act in conjunction with gases to increase the effect on the body. Small particles suspended in the air are chiefly responsible for reduced visibility.

The data in Table II-75 provides an indication of the maximum pollutant concentration observed in 1970 in California. The South Coast and San Diego Air Basins are of particular interest since they comprise the study area. As seen, the South Coast Air Basin experienced a greater level of pollution in 1970 than any other region, while at

Table II-75
Maximum Pollutant Concentrations
Observed in 1970
By
State of California Air Basins

Air Basins	Carbon Monoxide	Nitrogen Dioxide	Oxidant	Particulate Matter	Sulfur Dioxide
	8 Hr. Average ppm	Annual Average ppm	1 Hr. Average ppm	AGM* - ug/m ³	Annual Average ppm
Nat'l. Primary Standards	9	.05	.08	75	.03
Nat'l. Secondary Standards	9	.05	.08	60	.02
North Coast	-	-	-	104	Less than .01
Bay Area	13	.05	.30	84	Less than .01
North Central Coast	6	.02	.11	67	-
South Central Coast	7	.02	.12	72	-
South Coast	41	.09	.62	127	.03
Northeast Plateau	-	-	-	-	-
Sacramento Valley	22	.03	.24	57	Less than .01
San Joaquin Valley	15	.05	.21	169	Less than .01
Great Basin Valley	-	-	-	-	-
Southeast Desert	12	-	.46	128	-
San Diego	16	.03	.40	87	Less than .01

*Annual Geometric Mean

Source: State of California, Resources Agency - Air Resource Board, Air Pollution in California, Annual Report 1972, p.10.

the same time, recording maximum readings for an excess of national primary and secondary standards. The maximum reading for sulfur dioxide was the same as the national primary standard.

The distribution of air pollutant emissions for the study area in terms of a percent of total emissions within California is shown in Table II-76. The data indicated that the South Coast Air Basin, which includes the Los Angeles Metropolitan Area, is responsible for almost half of all State emissions of organic gases, oxides of nitrogen, carbon monoxide, and sulfur dioxide. The data also revealed substantially lower readings for the two air basins to the north and to the south. Primary particulate matter did not constitute a major problem for the South Coast air basin. However, secondary particulate matter formed by chemical reactions in the atmosphere is of major concern in the area as discussed in the recent report for the Air Resources Board, "Characterization of Aerosols in California (ACHEX)".

The quality of the air within the study area is constantly studied by the technical service staff of the respective air pollution control districts. An air monitoring network of permanent air monitoring stations records contaminant concentrations in a twenty four hour period. The primary purpose of the monitoring system is to prevent an excessive buildup of air contaminants and to avoid the occurrence of an air pollution crisis. The system provides the necessary data which is used by decision makers when formulating programs leading to preventative programs.

The most typical characteristic of air pollution found in the study area is the oxidizing effect. Research has demonstrated that the characteristic oxidizing effect is due primarily to the formation of ozone in the atmosphere when complex reactions involving hydrocarbons and nitrogen oxides occur in the presence of sunlight. Since the reactions require sunlight energy to make them occur, they are called

Table II-76

Distribution of
Air Pollutant Emissions
As Percent of Total Emissions
in California
1972

Pollutants	AIR BASINS			Tons Per Day Emitted in California
	San Diego	South Coast	South Central Coast	
Organic Gases	5.2	44.0	1.2	7,260
Oxides of Nitrogen	6.2	46.0	1.6	3,399
Carbon Monoxide	6.1	45.0	1.1	25,300
Sulfur Dioxide	4.5	41.0	1.4	764
Particulate Matter	13.0	16.0	1.8	1,470

Source: State of California, Resources Agency - Air Resources Board. Air Pollution in California, Annual Report 1972, pp. 7-8.

photochemical reactions, and the resulting air pollution is known as photochemical smog.

Hydrocarbons and nitrogen oxides enter the atmosphere, and a series of smog forming photochemical reactions begin with its conversion to nitrogen dioxide (NO_2). This compound subsequently absorbs certain light energy from the sun, and further reactions form a variety of products, including ozones. Ozone does not accumulate, however, until all of the nitric oxide has been used up.

Meteorological conditions such as temperature inversions and wind speed are highly significant to the pattern of an ozone alert. A combination of low wind speeds, and low temperature inversions forms the accumulation of air pollutants.

Wind speeds in downtown Los Angeles between 6 a.m. and noon on alert days averaged 4.0 mph, which is lower than normal. Since 1950 the annual average windspeed during these hours has been 5.1 mph, and the average for the months of July through October has been 4.4 mph. However, wind speeds can vary considerably with height and this can be an important factor in pollutant transport.

The strong temperature inversions (when air at higher altitudes is warmer than air at lower altitudes) which persist above the South Coast Air Basin during the late summer and early fall play a key role in the creation of photochemical air pollution problems. Emissions from the ground, which normally would diffuse upward in an unrestricted manner, stop at the base of the inversion layer and are confined in the volume of air below the inversion base. The height of an inversion base changes during the day, as do temperature and other factors, and a lifting or breaking of the temperature inversion often means an end

to the alert or period of high ozone concentration.

The maximum mixing height, which is the maximum altitude to which the inversion base rose on a given day must also be considered. When wind speed, inversion base, and maximum mixing height are all lows on a typical alert day, the air temperature is usually higher than normal. For example, the average maximum temperature in downtown Los Angeles on alert days was 89°F. This value is higher when compared with either the annual average maximum of 74°F or the July-October average maximum of 81.6°F. A meteorological profile can be drawn from the preceding information of the kind of day which might be considered a typical alert day. It is one on which the early morning inversion base was less than one hundred feet. The average wind speed between 6 a.m. and noon was about four mph or less, the maximum temperature in the basin was 89°F and occurred during a summer month.

The above data substantiates the seasonality of photochemical air pollution in the study area. The period from June through October is recognized as the actual time for air pollution problems. The following information reveals the increased concentration of ozone in the summer months as opposed to that found during the winter in Los Angeles.

Table II-77

Ozone Concentrations
Parts per Million

Monitoring Station	Summer			Winter		
	Ave			Ave		
	Qtrly Avg	Daily Max	Qtrly Max	Qtrly Avg	Daily Max	Qtrly Max
1	.037	.13	.36	.014	.04	.18
60	.059	.21	.49	.018	.05	.18
69	.041	.14	.33	.015	.04	.17
71	.035	.10	.41	.015	.04	.17
72	.020	.06	.18	.014	.04	.13
74	.049	.15	.31	.016	.03	.13
75	.049	.18	.35	.015	.04	.13
76	.018	.06	.19	.014	.04	.10
80	.027	.09	.25	.017	.05	.16
81	.067	.19	.33	.016	.03	.14
82	.080	.13	.22	.017	.03	.07
83	.057	.19	.48	.018	.05	.19

Source: Los Angeles Air Pollution Control District handout sheet.

The 1973 Annual Report on air pollution in California presents information on the South Coast Air Basin and the San Diego Air Basin in terms of sources and trends of pollution. The following information contained in Table II-78 indicates the percentage of emissions from major sources within the respective air basins. Both basins record a similar picture as to emissions caused by motor vehicles. The major difference is in the percentage of nitrogen oxides emissions from motor vehicle. The figure is almost half again as much in the San Diego Basin as found in the South Coast Air Basin.

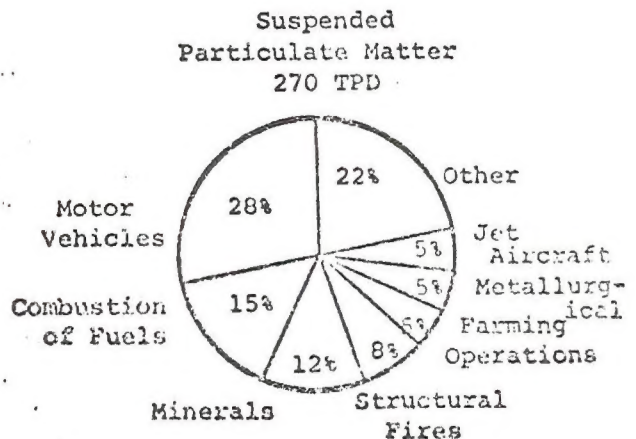
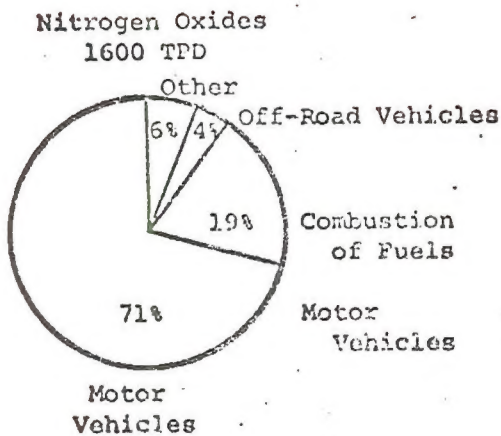
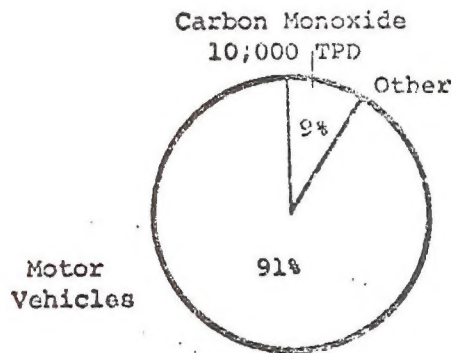
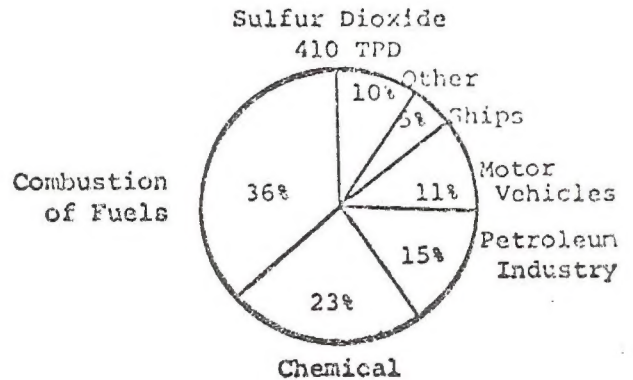
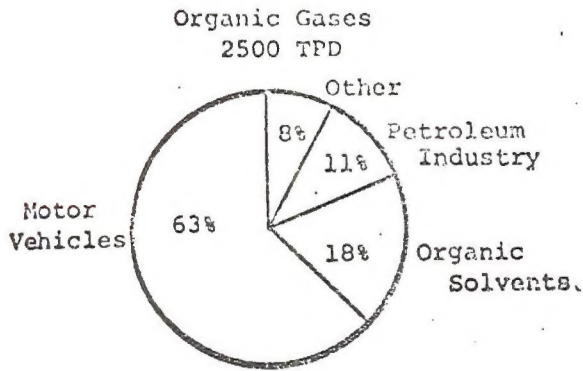
The trend of three pollutants within the South Coast Air Basin from 1964 through 1973 is shown in Table II-80. As indicated, the trend line for particulate matter, carbon monoxide, and for oxidant have shown steady declines since 1965. However as seen from Table II-80a, the oxidant concentrations in the eastern portion of the basin in San Bernardino have been increasing since 1972. San Bernardino experienced its worst year in history for oxide concentrations in 1974. Table II-81 shows the trend lines for eye irritation, ozone concentrations, and for oxides of nitrogen within the Los Angeles Air Basin from 1956 to 1971. As indicated, the number of days recording eye irritation ozone concentrations have declined for both categories over the study period. The levels of concentration for oxides of nitrogen, however, increased over the same period.

Table II-84 graphically presents a pollution trend within the San Diego Air Basin for particulate matter, carbon monoxide, or for oxidants. With the exception of particulate matter, the indication is a general lessening of the carbon monoxide and oxidant concentrations. Charts showing other types of pollutants within the air basins are not available at this time.

Smog alerts occur when specified levels of concentrations have

TABLE II-78

PERCENTAGE OF EMISSIONS
FROM MAJOR SOURCES IN SOUTH COAST AIR BASIN
1972

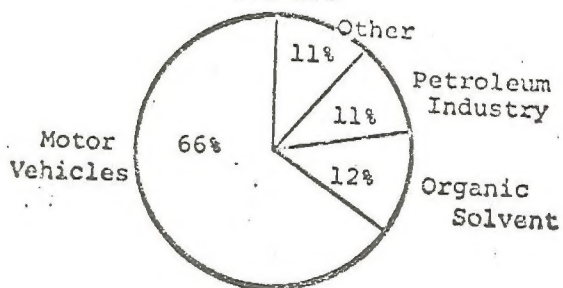


Source: Air Pollution in California Annual Report 1973, State of California
Air Resource Board, p. 25

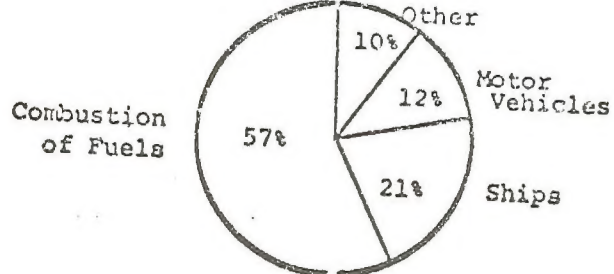
Table II-79

PERCENTAGES OF EMISSIONS
FROM MAJOR SOURCES IN SAN DIEGO AIR BASIN
1972

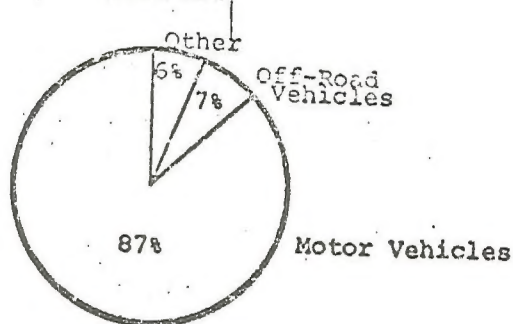
Organic Gases
340 TPD



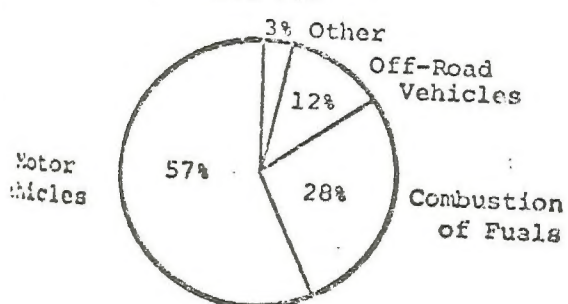
Sulfur Dioxide
53 TPD



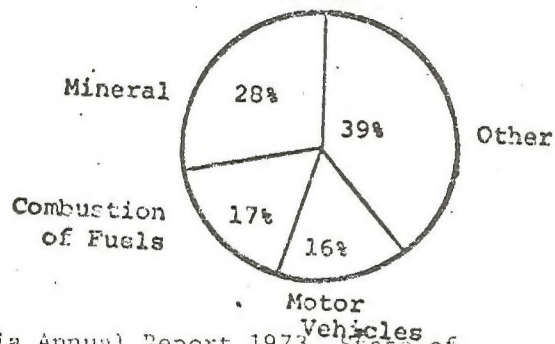
Carbon Monoxide
1400 TPD



Nitrogen Oxides
290 TPD



Suspended Particulate Matter
65 TPD

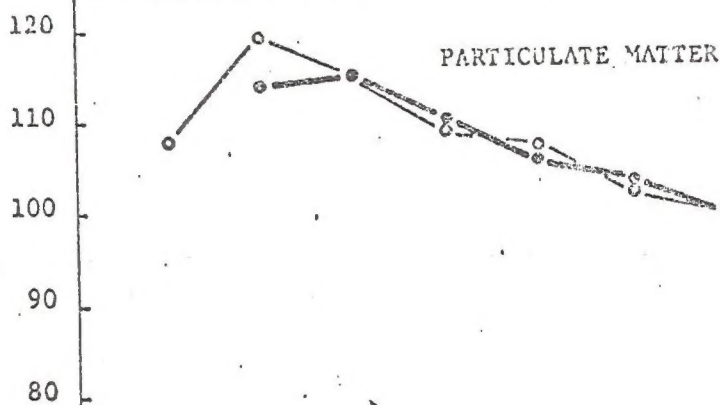


Source: Air Pollution in California Annual Report 1973, State of California Air Resources Board p. 26

Table II-80
 POLLUTANT TRENDS
 SOUTH COAST AIR BASIN

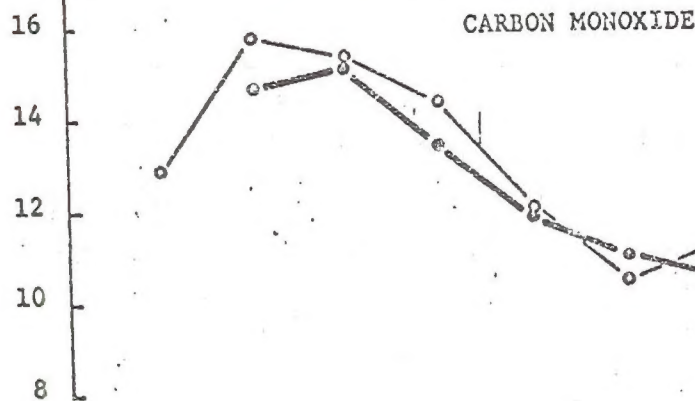
PARTICULATE MATTER

Annual Geometric Mean,
 $\mu\text{g}/\text{m}^3$



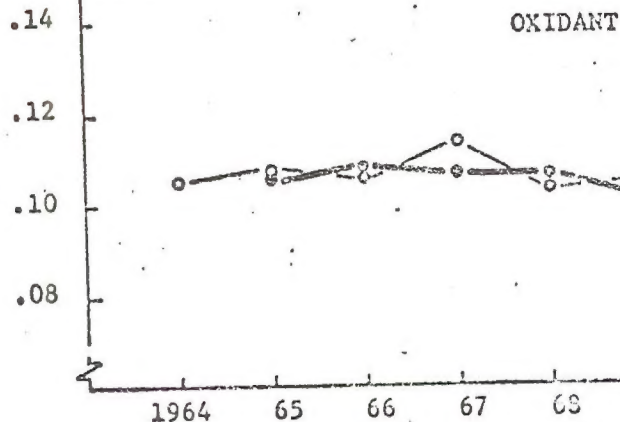
CARBON MONOXIDE

Max-Hour Average,
 ppm



OXIDANT

Max-Hour Average,
 ppm



○—○ Annual Average

Source: Air Pollution Three-Year Moving Average
 Air Pollution in California Annual Report, 1973, State of
 California Air Resources Board, p. 25

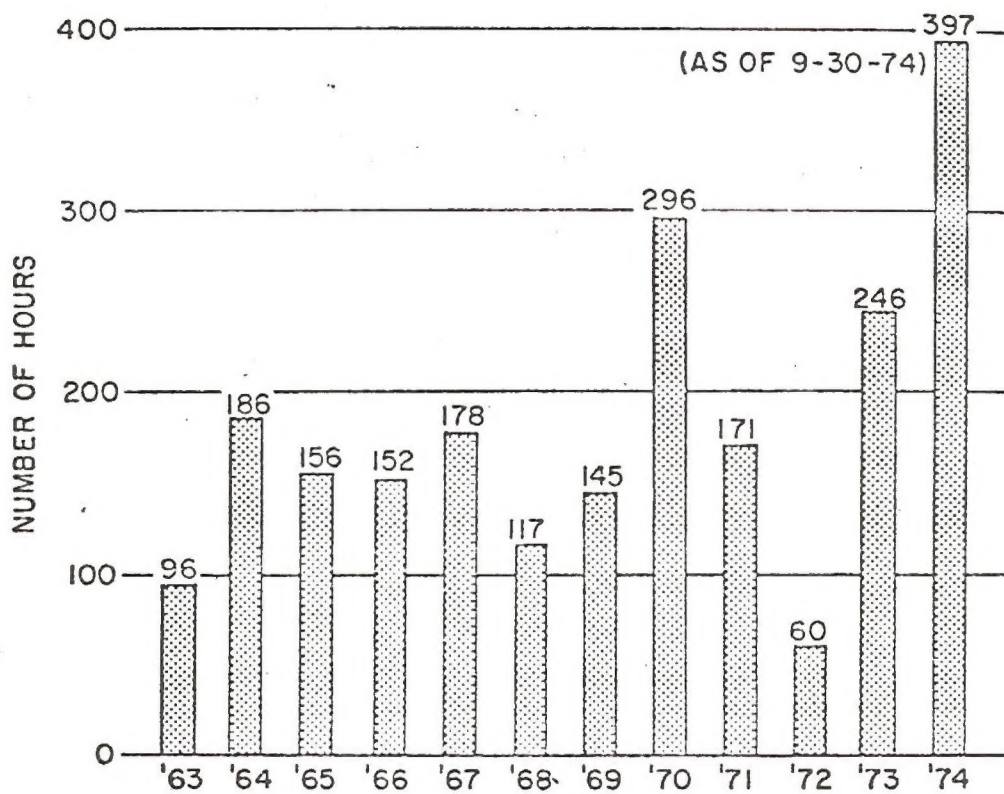
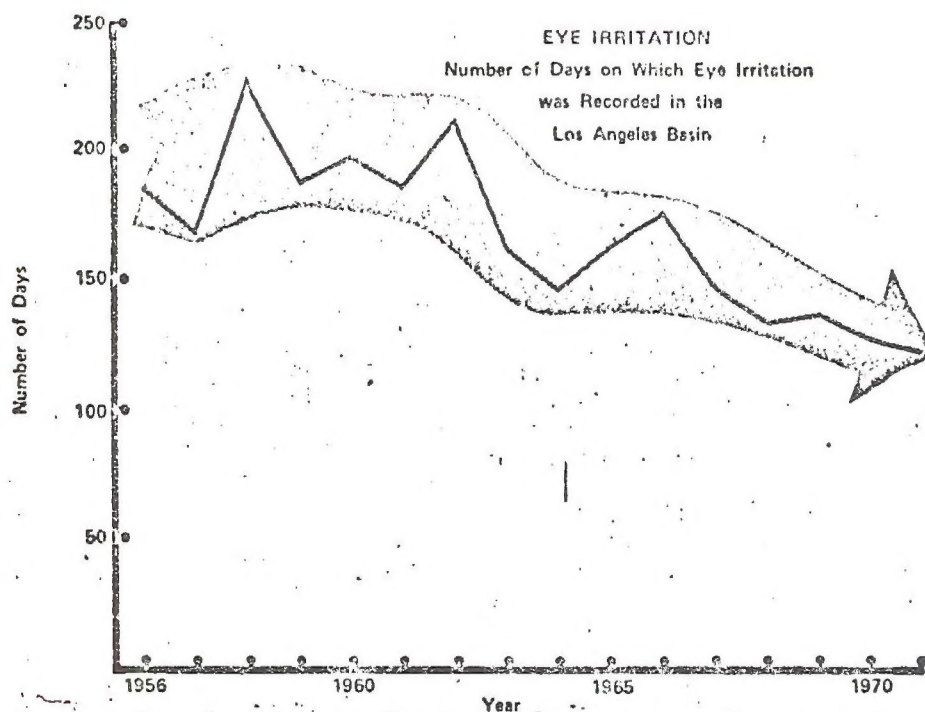


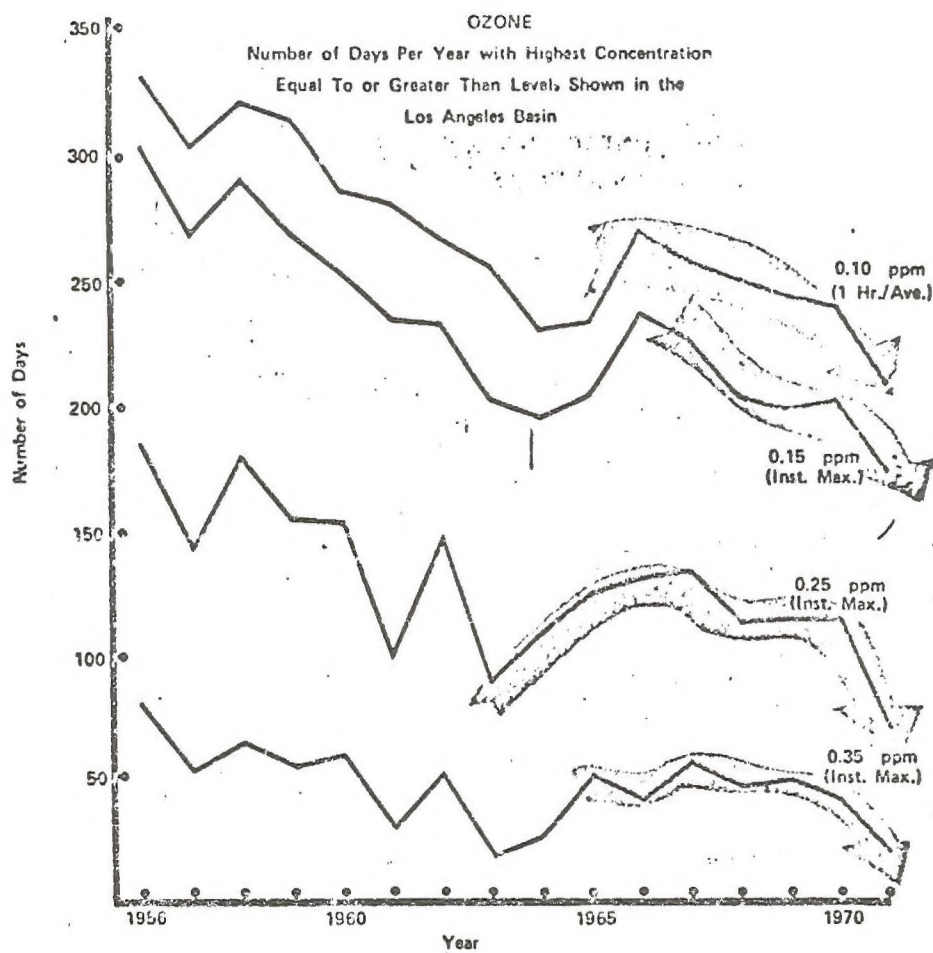
Table II-80a Number of hours per year for which the hourly average oxidant concentration equaled or exceeded 0.20 ppm at San Bernardino air monitoring station. (Data from San Bernardino County Air Pollution Control District.)

TABLE II-81



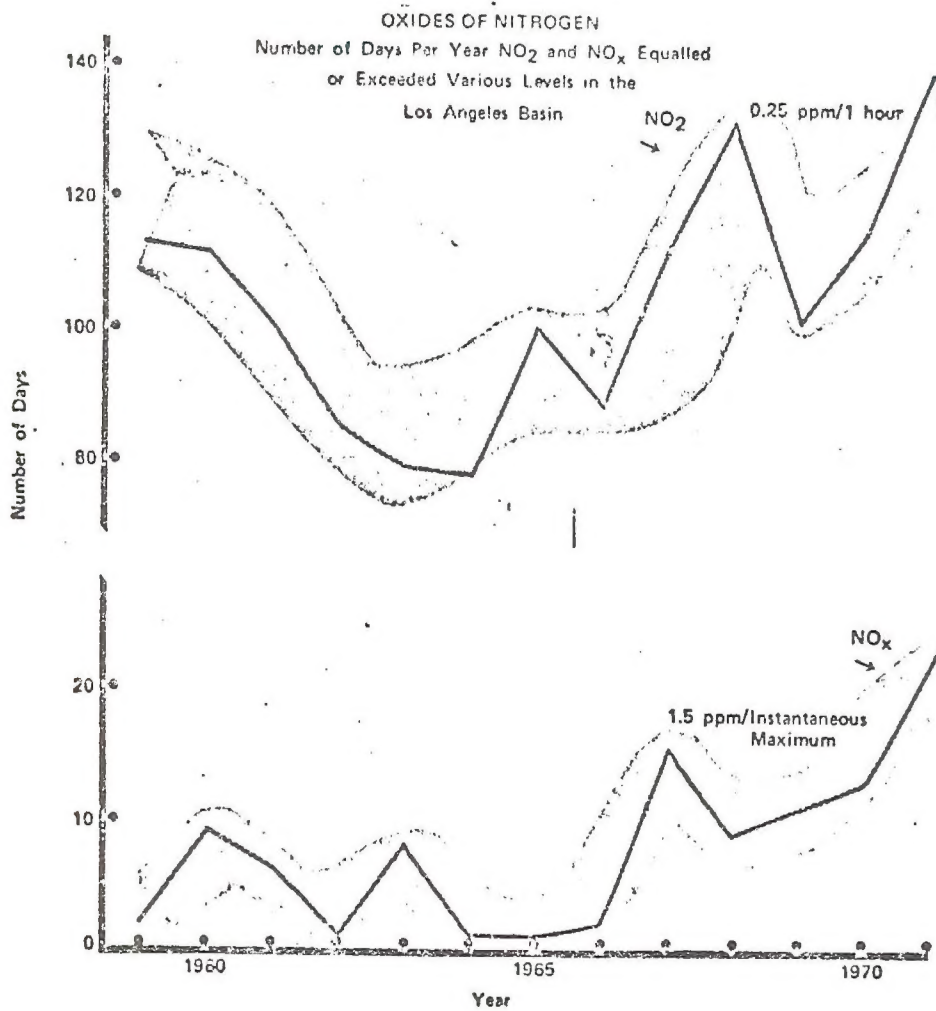
Source: APCD Digest, County of Los Angeles, May 1972, p. 3

TABLE II-82



Source: APCD DIGEST, County of Los Angeles, May 1972, p. 2

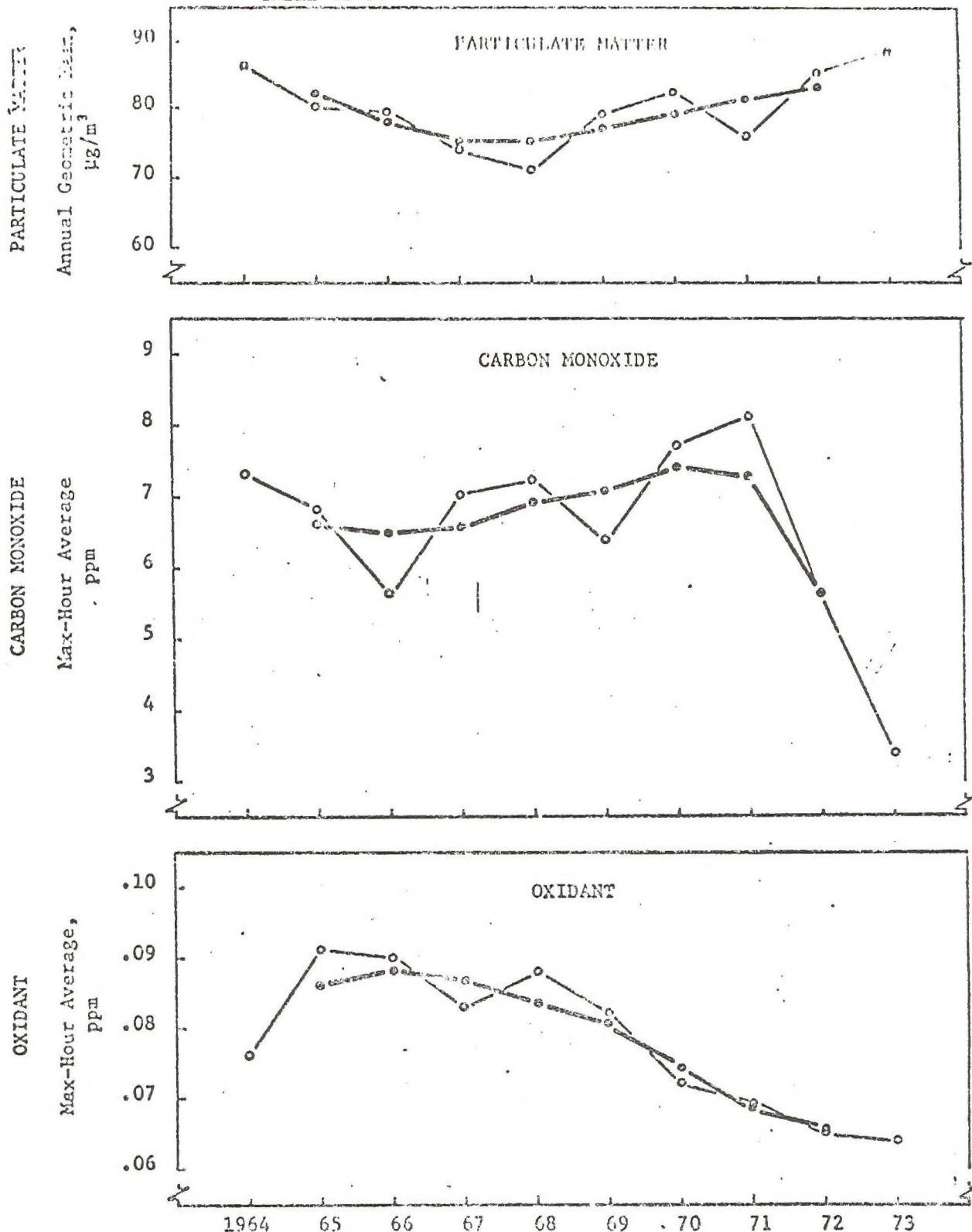
TABLE II-83



Source: APCD DIGEST, County of Los Angeles, May 1972, p. 4

SAN DIEGO AIR BASIN

TABLE II-84



Source: Air Pollution in California Annual Report 1973, State of California Air Resources Board, p. 17

○ Annual Average

— Three-Year Moving Average

been met or exceeded. The Los Angeles Air Pollution Control District program for alerts is shown as an example of the operation of such a warning system.

	<u>Concentration PPM</u>			
	<u>School & Health Smog Warning</u>	<u>1st Alert</u>	<u>2nd Alert</u>	<u>3rd Alert</u>
Carbon Monoxide	40	50	100	150
Nitrogen Oxide	1.5	3	3	10
Sulfur Oxide	No Warning	3	5	10
Ozone	.35	050	1.00	1.50

Source: Smog Alerts, Los Angeles Air Pollution Control District, No Date, p. 4

First Alert: Close approach to maximum allowable concentration for population at large, a point where preventive action is required.

Second Alert: Air contamination level at which a dangerous health menace exists.

The school health and smog warning is to curtail strenuous activities for students with the onset of moderately high air pollution levels. In addition, the program is intended to warn individuals with cardiac or respiratory diseases or other sensitivity to air pollution effects of such levels, enabling them to take precautions in order to avoid discomfort or aggravation of health problems.

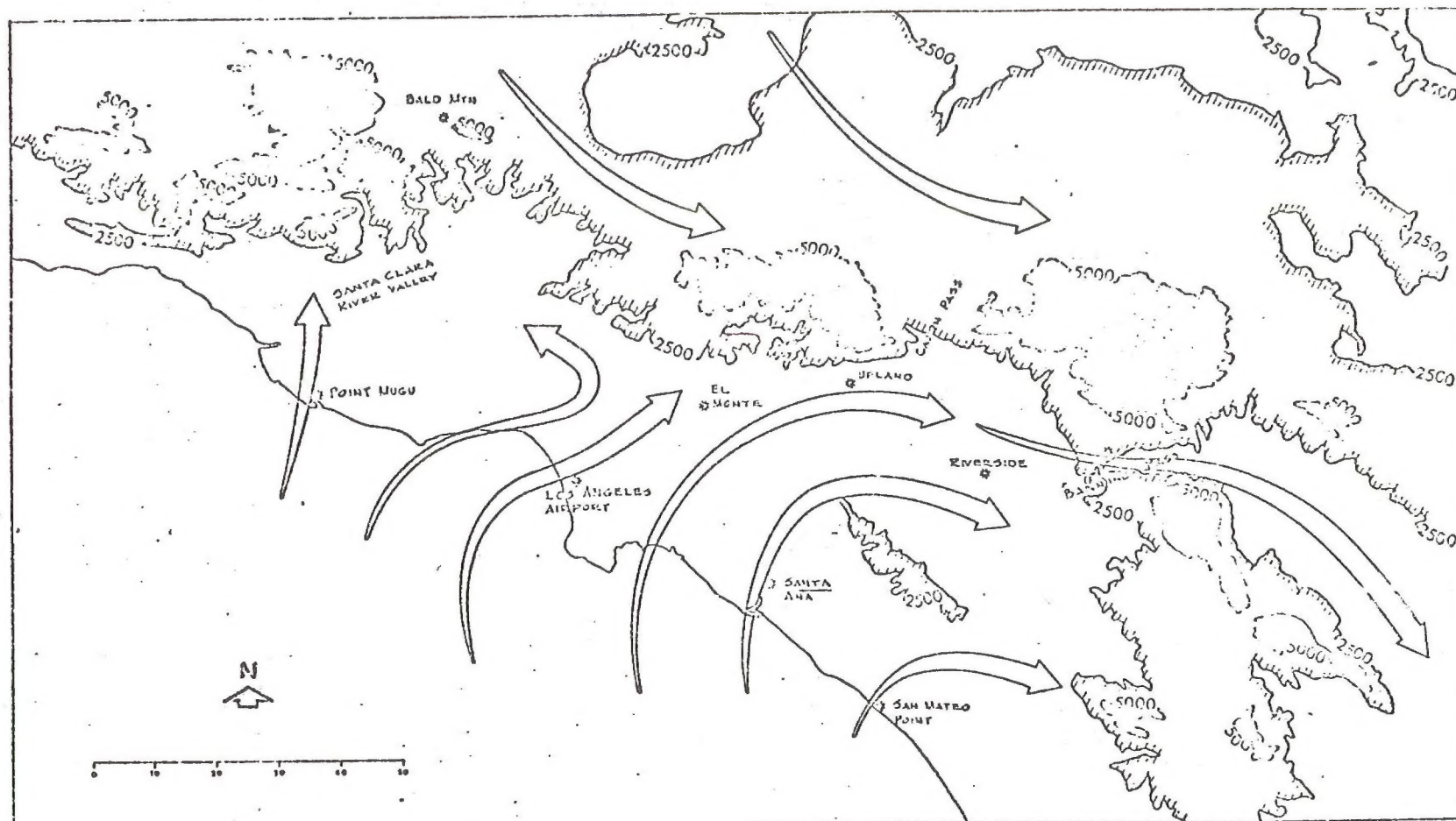
The common border separating the United States and Mexico does not prevent air pollutants from leaving the San Diego area and entering into Mexico. The San Diego Air Pollution Control District indicates that even though Mexico has an air pollution control organization, no major problem exists in the Baja California portion of the country. As a result, no program for control or abatement exists for the State of Baja California.

The offshore areas of Southern California are prone to receiving some onshore air pollution because of the meteorological conditions that occur. The prevailing wind during the greater part of the year is from the northwest, a direction that brings it nearly parallel to the coast. There are, however, occasions when warm dry descending winds from the northeast and east come roaring through the major passes of the coastal mountains. These winds, often accompanied by desiccating temperatures, may exceed forty-five knots and at times carry considerable dust. (Environmental Science Services Administration, 1968, 103).

The strong onshore winds are referred to as Santa Ana winds and characterized as desert winds. These winds diminish little, if any, immediately after passing over water, and some reports credit them with blowing considerable distances at sea. However, beyond fifty miles from shore they are usually of no particular concern (Environmental Science Services Administration, 1968, 104).

Examples of the wind patterns are shown on Map 1 and Map 2. The first map indicates the typical wind pattern for September and the second shows the pattern when the winds blow off the land.

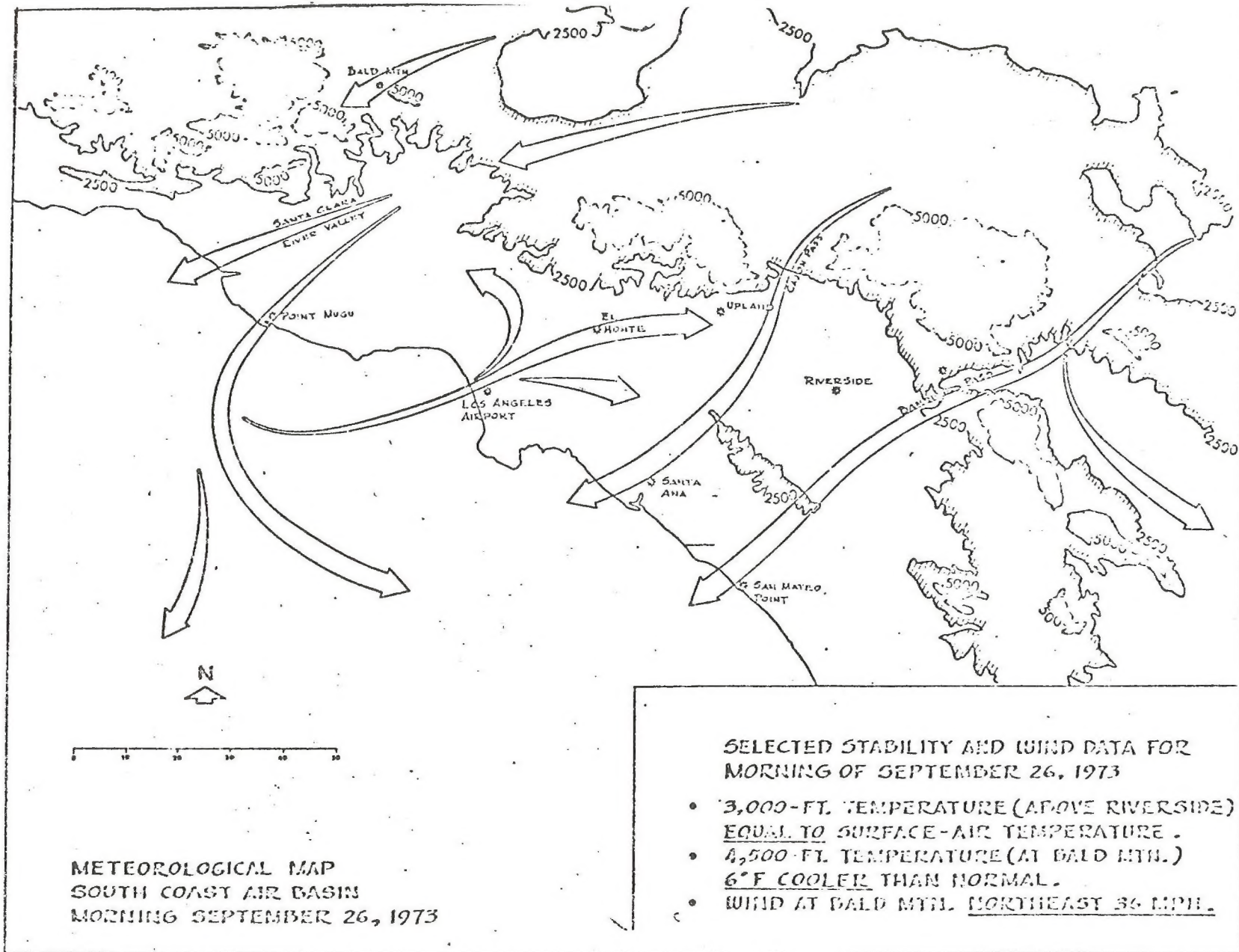
In terms of ocean pollution from the land mass, the Santa Ana conditions carry the pollutants out to sea. The Channel Islands are incorporated into the Air Pollution Control Districts of their respective counties, but no monitoring stations have been established to measure the air quality. A 1973 report by the Southern California Coastal Water Research Project indicates that limited data are available



METEOROLOGICAL MAP
SOUTH COAST AIR BASIN
MORNING SEPTEMBER 6, 1973

- SELECTED STABILITY AND WIND DATA FOR
MORNING OF SEPTEMBER 6, 1973.
- 3,000-FT TEMPERATURE (ABOVE RIVERSIDE)
21°F WARMER THAN SURFACE-AIR TEMP.
 - 4,500-FT TEMPERATURE (AT BALD MTL.)
7°F WARMER THAN NORMAL WIND AT
BALD MTL. NORTHWEST 15 MPH.

--Source: California Air Quality Data April, May, June, 1973,
State of California Air Resources Board, p. 4



on aerial fallout rates of trace constituents into the Southern California Bight. The report states that the source is difficult to quantitate for several reasons, including the high horizontal velocity compared to the vertical velocity of airborne particles, The diffuse nature of the source, the relatively high constituent gradients that may exist near the densely populated areas, and the large area of the Bight. The study further indicates that rainfall washout does occur, but it is possible that the contribution of particulate borne materials to the Bight via dry fallout may exceed those due to direct rainfall washouts. The study limited itself to metal emissions into the Bight and reported on copper, mercury, nickel, lead, zinc, iron, and managanese.

Chow and Earl (1970) reported that in 1968 approximately 23,000 M tons of lead are released annually to the atmosphere of the area. As much as one third of the amount may fall directly into the coastal waters. (Southern California Coastal Water Research Project, 1973, pp. 110-111).

2. Past and Potential Sources of Water Quality Degradation

Marine water pollution within the Southern California Bight area is mainly of terrestrial origin. Areas of study in the Southern California Bight are seen in Figure II-107. The largest single source is municipal waste waters discharged directly into the ocean from twenty-five outfalls between Point Conception and the Mexican Border. This area encompasses the counties of Santa Barbara, Ventura, Los Angeles, Orange and San Diego. Los Angeles County discharges the largest amount into coastal waters with 707.30 mgd (million gallons/day), followed by Orange County with 139.75 mgd, San Diego 99.56 mgd, Santa Barbara County 15.05 mgd and Ventura County 14.05 mgd, (Reed & Bakker 1974). "As of January 1, 1972, there were 22 major municipal dischargers of waste water on the coastal area that on the average discharged nearly 1,000 mgd of partially treated municipal sewage into the coastal basin" (Reed & Bakker 1974). Five of the twenty-two major dischargers generate 932 mgd or 96 percent of the total municipal waste dumped into the marine waters of the area.

The five major dischargers are: Los Angeles County Sanitation Districts Joint Water Pollution Control Plant (365.05 mgd), city of Los Angeles Hyperion Treatment Plant (333.16 mgd), Orange County Sanitation Districts Plants 1 and 2 (134.62 mgd), city of San Diego Point Loma Plant (88.91 mgd) and city of Oxnard Treatment Plant (9.85 mgd).

The Los Angeles County Sanitation District's Joint Water Pollution Control Plant discharges the greatest amount of effluent (365.05 mgd) by way of three outfalls (2000, 2600 and 3600 meters in length at respective ocean depths of 50, 65, and 60 meters) off Whites Point on the

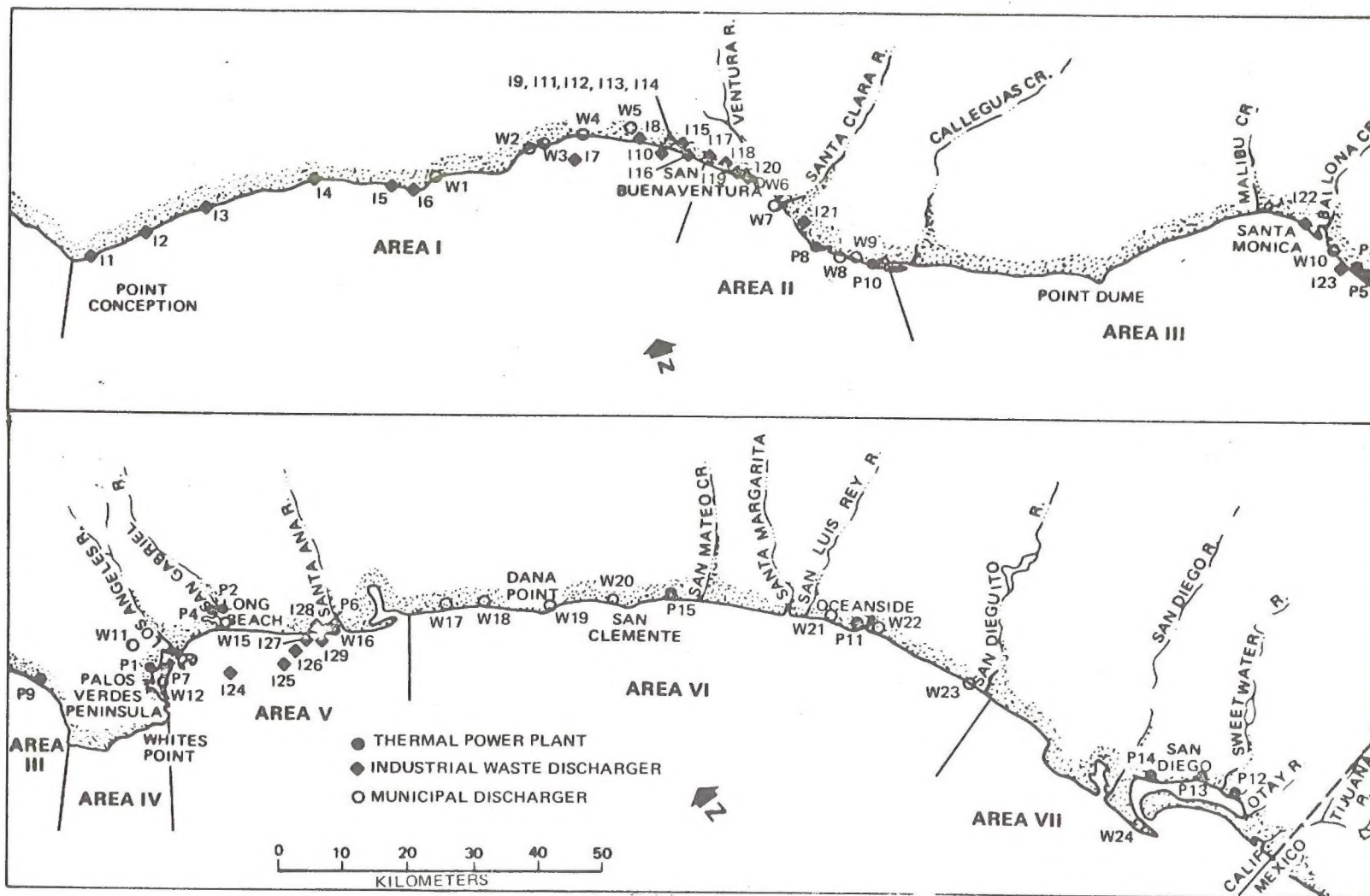


Figure II-107. Areas of Study in Southern California. From: Southern California Coastal Water Project Report TR 104 (March, 1973).

Palos Verdes Peninsula. The city of Los Angeles Hyperion Plant is second with 333.16 mgd, discharge by way of two outfalls (8,000 & 11,000 meters in length and at a respective ocean depths of 60 and 100 meters) into Santa Monica Bay off of El Segundo. The Los Angeles County Sanitation District and Los Angeles Hyperion Plant discharge 73% of the municipal waste into the Bight Area. The Orange County Sanitation District's Plant 1 and 2 (134.62 mgd) increases the combined discharge for the three municipalities to 87% of the total municipal discharge into the coastal waters.

From final effluent data of five of the major treatment plants in Southern California, SCCWRP (1974) has estimated the 1972 and 1973 mean yearly concentration of 28 wastewater constituents. The constituents of the waste waters for the five major treatment plants in Southern California are seen in Table II-85. The mass emission rates of the constituents presented in Table II-85 are given in Table II-86.

The State of California has two sets of concentration limits for various municipal waste parameters. One set consists of concentrations that are not to be exceeded more than 50 percent of the time, the other, concentrations not to be exceeded more than 10 percent of the time. Monthly mean concentrations are available for all dischargers except Ventura County, which only has quarterly data for trace metals and chlorinated hydrocarbons. Based on these data, SCCWRP (1974) performed a review of the major dischargers' capability to meet the State water quality standards in 1973. Table II-87 presents the results for the 50 percent standard and Table II-88 for the 10 percent requirement. These tables indicate the degree to which each discharger exceeded the concentration limits for any given parameter during the year: The number on the left of the column is the percentage of time* that the limit was exceeded, and the number to the right is the average of the concentrations that exceeded the limit.

* Based on the twelve monthly values, or four quarterly values for Oxnard's metal parameters.

Table II-85 Average concentrations of general constituents, trace metals, and chlorinated hydrocarbons in the final effluent of municipal waste dischargers, 1973. (SCCWRP, 1974)

	JWPCP	Hyperion 5-min	7-mi	Orange County	Point Loma	Oxnard
Flow (mgd)	359	339	4.82	152	99.6	12.1
General constituents (mg/L)						
Total suspended solids	258	81.3	7,500	154	157	127
Volatile suspended solids	177	62.4	4,620	104	118	—
5-day biological oxygen demand	226	98.4	—	167	179	171
Chemical oxygen demand	587	222	—	—	—	516
Oil and grease	59.2	17.9	922	40.2	36.2	23.4
Nitrate nitrogen	0.24	0.16	—	—	—	—
Ammonia nitrogen	59.5	13.0	—	35.7	20.6	—
Organic nitrogen	17.3	5.30	—	—	—	—
Total nitrogen	77.6	18.5	—	—	35.2	—
Total phosphate	47.8	24.9	—	—	38.3	—
Detergent (MBAS)	6.26	4.30	—	—	5.84	—
Cyanide	0.34	0.16	0.11	—	—	—
Phenols	3.63	0.060	—	—	0.31	—
Trace metals (mg/L)						
Silver	0.011	0.030	0.80	0.013	0.011	0.0092
Arsenic	0.015	0.012	0.27	—	0.010	—
Cadmium	0.027	0.018	0.98	0.078	0.033	0.0062
Total chromium	0.72	0.29	18.2	0.35	0.052	0.024
Copper	0.47	0.14	13.6	0.49	0.12	0.080
Iron	6.44	0.70	76.8	—	0.69	1.18
Mercury	0.0012	0.0026	0.14	—	0.0029	0.0012
Manganese	0.093	0.054	0.37	—	0.066	0.098
Nickel	0.31	0.17	3.57	0.26	0.046	0.068
Lead	0.21	0.045	1.57	0.17	0.060	0.067
Selenium	0.010	0.017	0.45	—	—	—
Zinc	1.78	0.25	27.0	0.58	0.36	0.27
Chlorinated hydrocarbons (µg/L)						
Total DDT	7.50	0.65	4.03	0.34	—	2.40
Total PCB	2.59	2.00	25.4	10.7	—	—
Dieldrin	0.054	0.0013	0.49	1.20	—	< 0.05

Table II-86 Mass emission rates of general constituents, trace metals, and chlorinated hydrocarbons in the final effluents of major municipal wastewater dischargers, 1973. (SCCWRP, 1974)

	JWPCP	Hyperion 5-mi	7-mi	Orange County	Point Loma	Oxnard
Flow (mgd)	359	339	4.82	152	99.6	12.1
General constituents (metric tons/yr)						
Total suspended solids	128,000	38,000	49,900	32,300	21,600	2,120
Volatile suspended solids	87,700	29,200	30,700	21,800	16,200	—
5-day biological oxygen demand	112,000	46,000	—	35,000	24,600	2,860
Chemical oxygen demand	291,000	104,000	—	—	—	8,620
Oil and grease	29,300	8,380	6,130	8,430	4,980	391
Nitrate nitrogen	119	74.9	—	—	—	—
Ammonia nitrogen	29,500	6,080	—	7,490	2,830	—
Organic nitrogen	8,570	2,480	—	—	—	—
Total nitrogen	38,400	8,650	—	—	4,840	—
Total phosphate	23,700	11,600	—	—	5,260	—
Detergent (MBAS)	3,100	2,010	—	—	803	—
Cyanide	168	74.9	0.73	—	—	—
Phenols	1,800	28.1	—	—	42.6	—
Trace metals (metric tons/yr)						
Silver	5.45	14.0	5.32	2.73	1.51	0.15
Arsenic	7.43	5.61	1.80	—	1.37	—
Cadmium	13.4	8.42	6.52	16.4	4.54	0.10
Total chromium	357	136	121	73.4	7.15	0.40
Copper	233	65.5	90.5	103	16.5	1.34
Iron	3,190	327	511	—	94.8	19.7
Mercury	0.59	1.22	0.93	—	0.40	0.020
Manganese	46.1	25.3	2.46	—	9.07	1.64
Nickel	154	79.5	23.7	54.5	6.32	1.14
Lead	104	21.1	10.4	35.7	8.25	1.12
Selenium	4.95	7.95	2.99	—	—	—
Zinc	882	117	180	122	49.5	4.51
Chlorinated hydrocarbons (kg/yr)						
Total DDT	3,720	304	26.8	71.3	—	40.1
Total PCB	1,280	936	169	2,240	—	—
Dieldrin	26.8	6.08	3.26	252	—	< 0.83

Table II-87 A comparison of the capabilities of the five major dischargers to meet the State of California's "50 percent" standards in 1973. (SCCWRP, 1974)

	50% Standard ^a (mg/L)	% ^b	JWPCP mg/L ^c	% ^b	Hyperion 5-mile mg/L ^c	% ^b	Hyperion 7-mile mg/L ^c	% ^b	Orange County mg/L ^c	% ^b	Point Loma mg/L ^c	% ^b	Oxnard mg/L ^c
General constituents													
Total suspended solids	50.0	100	260	100	81.0	100	7500	100	150	100	160	100	130
Ammonia nitrogen	40.0	58	78.0	0	—	NM ^d	—	8	42.0	0	—	NM	—
Oil/grease	10.0	100	59.0	100	18.0	100	920	100	40.0	100	36.0	83	26.0
Cyanide	0.1	100	0.34	83	0.17	33	0.16	NM	—	NM	—	NM	—
Phenols	0.5	100	3.6	0	—	NM	—	NM	—	25	0.57	NM	—
Trace metals													
Silver	0.02	0	—	50	0.037	87	0.96	0	—	8	0.035	0	—
Arsenic	0.01	44	0.025	33	0.020	100	0.27	NM	—	42	0.016	NM	—
Cadmium	0.02	100	0.027	25	0.033	100	0.98	100	0.078	58	0.047	0	—
Total chromium	0.005	100	0.72	100	0.29	100	18.0	100	0.35	100	0.052	100	0.024
Copper	0.2	100	0.47	8	0.24	100	14.0	100	0.49	25	0.23	0	—
Mercury	0.001	58	0.0015	100	0.0026	100	0.14	NM	—	36	0.0070	50	0.0020
Nickel	0.1	100	0.31	83	0.20	100	3.6	100	0.26	8	0.18	50	0.13
Lead	0.1	92	0.22	0	—	100	1.6	92	0.17	17	0.14	0	—
Zinc	0.3	100	1.8	17	0.34	100	27.0	100	0.58	50	0.51	50	0.44
Total identifiable chlorinated hydrocarbons	0.002	100	0.010	58	0.0038	92	0.033	75	0.011	NM	—	50	0.0028

^aConcentration designated by the State as not to be exceeded more than 50 percent of the time.

^bPercent of the time discharger exceeded the "50 percent" limit.

^cAverage of the concentrations that exceeded the limit.

^dNM = not measured.

Table II-88 A comparison of the capabilities of the five major dischargers for meeting the State of California's "10 percent" standards in 1973. (SCCWRP, 1974)

	10% Standard ^a (mg/L)	% ^b	JWPCP mg/L ^c	% ^b	Hyperion 5-mile mg/L ^c	% ^b	Hyperion 7-mile mg/L ^c	% ^b	Orange County mg/L ^c	% ^b	Point Loma mg/L ^c	% ^b	Oxnard mg/L ^c
General constituents													
Total suspended solids	75.0	100	260	100	81.0	100	7500	100	150	100	160	83	140
Ammonia nitrogen	60.0	42	91.0	0	—	NM ^d	—	0	—	0	—	NM	—
Oil/grease	15.0	100	59.0	100	18.0	100	920	100	40.0	100	36.0	50	36.0
Cyanide	0.2	100	0.34	17	0.21	0	—	NM	—	NM	—	NM	—
Phenols	1.0	92	3.9	0	—	NM	—	NM	—	0	—	NM	—
Trace metals													
Silver	0.04	0	—	17	0.05	83	0.96	0	—	0	—	0	—
Arsenic	0.02	22	0.030	0	—	100	0.27	NM	—	8	0.023	NM	—
Cadmium	0.03	25	0.032	8	0.04	92	1.1	100	0.078	33	0.063	0	—
Total chromium	0.01	100	0.72	92	0.32	100	18.0	100	0.35	83	0.061	100	0.024
Copper	0.3	100	0.47	0	—	100	14.0	100	0.49	0	—	0	—
Mercury	0.002	0	—	58	0.0033	100	0.14	NM	—	9	0.024	0	—
Nickel	0.2	100	0.31	17	0.34	100	3.6	92	0.27	0	—	0	—
Lead	0.2	50	0.26	0	—	100	1.6	8	0.25	0	—	0	—
Zinc	0.5	100	1.8	0	—	100	27.0	83	0.60	33	0.57	25	0.56
Total identifiable chlorinated hydrocarbons	0.004	100	0.010	17	0.0058	92	0.033	75	0.011	NM	—	0	—

^aConcentration designated by the State as not to be exceeded more than 10 percent of the time.

^bPercent of the time discharger exceeded the "10 percent" limit.

^cAverage of the concentrations that exceeded the limit.

^dNM = not measured.

In 1973, the 50 percent standards for silver and arsenic were met by all discharges, except that of the Hyperion's 7-mile outfall. On the other hand, none of the dischargers met either standard for total suspended solids, oil/grease, and total chromium.

JWPCP effluent, with its high load of industrial input, did not meet either the 50 percent or 10 percent State requirements for any parameter, except silver. Orange County Sanitation District had a similar problem meeting these standards, except for those for silver and ammonia-nitrogen.

The Hyperion 5-mile effluent exceeded the standards for cyanide, total chromium, mercury, and nickel; the 7-mile effluent exceeded all the standards except for cyanide by at least a factor of 10 and was 1,800 times too high in total chromium. Point Loma effluent also exceeded the standards for three metals--total chromium, cadmium, and zinc, and Oxnard effluent exceeded the standards for total chromium and zinc.

The three major dischargers--JWPCP, Hyperion, and Orange County--all exceeded both limits for total identifiable chlorinated hydrocarbons. (No reliable monitoring data on these constituents is available for Oxnard and Point Loma.)

An extensive examination of the monitoring data from the five dischargers for the 3-year period 1971 to 1973 will be presented in an upcoming technical memorandum.

In considering the municipal wastewater inputs, it is important to realize that a discharger's failure to meet the State standards does not necessarily mean that the discharge is damaging to the marine environment. The standards are based on available scientific information. But, as pointed out throughout this report, there are a number of uncertainties about the fates and effects of each wastewater constituent, and in many cases, it was necessary to set the standard without sufficient information: It is our goal to provide as much of this information as possible. (SCCWRP, 1974)

In addition to 25 (SCCWRP 1973) municipal waste treatment plants which discharge directly into the marine coastal waters there are an additional eighty-three plants which discharge onto the land or water courses and may be considered as contributing ultimately to marine pollution.

Other sources of pollution originate from industrial processes, pollution from electric generating plants, terrestrial runoff, offshore dumping, serial fallout, dredging and day to day use of the marine environment by the public.

Industrial wastes are the second largest source of pollution (Southern California Coastal Water Research Project 1973, SCCWRP), finding their way into the ocean from municipal waste water treatment facilities, direct ocean discharge, estuary and tributary discharge, and ocean dumping. The SCCWRP report notes with the exception of one industrial plant (Table II-89) the entire industrial (non power) waste discharge into marine waters is from petroleum related industries (oil brine, tanker ballast, refinery waste). This includes onshore and offshore oil production, transport, processing and oil tanker mooring facilities.

These direct ocean industrial dischargers are grouped in three main areas, Santa Barbara Channel, Santa Monica Bay, and the northern coast of Orange County. Direct ocean discharge of industrial wastes into the bight area contribute about 6% of the total suspended solids, 14% of the total oil and grease, 2% of the total biochemical oxygen demand, and 10% of the total chemical oxygen demand (Table II-90).

The San Pedro Bay and northern coast of Orange County, leads the areas of industrial pollution with 80% of the total industrial suspended solids, 100% of the total industrial 5-day biochemical oxygen demand, 55% of the total industrial chemical oxygen demand and 36% of the total industrial oil and grease. The Santa Monica Bay area is the second largest area of industrial pollution with 18% of the total industrial suspended solids, 0% of the total industrial 5-day biochemical oxygen demand, 23% of the total industrial chemical oxygen demand and 61% of the total industrial oil and grease. All of the aforementioned percents

Table II-89 From: SCCWRP (1973)

DISCRETE INDUSTRIAL WASTE DISCHARGERS ON THE SOUTHERN CALIFORNIA COAST

Area	Discharger	Type of Waste	Flow (mgd)	Pipe Length (m)	Depth (m)	Reference to Tab. 3-9 & 3-10
I	I1 Phillips Petroleum--Point Conception	Oil brine Tanker ballast	0.2			T1, E1
	I2 Texaco, Inc.--San Augustin	Oil brine	0.2			E2, E3
	I3 Getty Oil--Gaviota	Oil brine Tanker ballast	0.16			T2
	I4 Shell Oil--El Capitan	Oil brine Tanker ballast	0.2			T3
	I5 Signal Oil & Gas--Ellwood	Oil brine Tanker ballast	0.29			T4
	I6 Atlantic Richfield--Coal Oil Point	Oil brine	0.06			E9, E10
	I7 Standard Oil--Summerland	Oil brine	0.4		32	E11
	I8 Standard Oil--Carpinteria	Oil brine Tanker ballast	0.4	120	3	T5
	I9 Atlantic Richfield--Rincon	Oil brine	0.01	76	6	
	I10 Atlantic Richfield--Rincon Island	Oil brine	0.04	800	18	E15
	I11 Western Oil & Dev.--Rincon	Oil brine	0.36		3	
	I12 Petrol Industries--Rincon	Oil brine	0.01			
	I13 Continental Oil--Rincon	Oil brine	0.49	150	4	
	I14 Norris Oil Co.--Rincon	Oil brine	0.05	670	3	
	I15 Phillips Petroleum--La Conchita	Oil brine	0.36	270	6	
	I16 Phillips Petroleum--Punta Garda	Oil brine	0.4	150	6	
	I17 Mobil Oil--Sea Cliff	Oil brine Tanker ballast	0.18	950	9	
II	I18 Continental Oil--Pitas Point	Oil brine	0.27	150	4	
	I19 Continental Oil--Grubb Lease	Oil brine	0.75	150	2	
	I20 Getty Oil--Ventura	Oil brine Tanker ballast	0.06		3	T7
	I21 Standard Oil--McGrath Beach	Oil brine	0.14		1	
III	I22 McDonnell Douglas Corp.--Venice	Cooling tower bleedoff	0.65			
	I23 Standard Oil--El Segundo	Cooling water Refinery Waste	72.0	170	5	T9
V	I24 Standard Oil--Island Esther	Oil brine	1.0			E18
	I25 Union Oil--Platform Eva	Oil brine	0.02			E19
	I26 Signal Oil and Gas--Platform Emmy	Oil brine	0.08			E20
	I27 Signal Oil and Gas--Huntington Beach	Oil brine	0.6	300	3	
	I28 Standard Oil--Huntington Beach	Oil brine	0.8	310	4	
	I29 Gulf Oil--Huntington Beach	Oil line ballast	0.01	300		T10

Table II-90

SUMMARY OF GENERAL CONSTITUENT MASS EMISSION RATES (M tons/yr)
FROM DISCRETE SOURCES, 1971-1972*

Area	Flow* (10 ⁶ cu m/yr)	Silt	Total Suspended Solids	Volatile Suspended Solids	5-day Biol. Oxy. Demand	Chemical Oxygen Demand	Oil and Grease	Dissolved Silica (SiO ₂)	Nitrate Nitrogen
I. Muni. wastewaters	22		2,000	1,500	3,000	7,000	1,000	1,000	4
Surface runoff	3.7	200				<1,000	<100	100	24
Indust. waste	5.2		300			12,000	<100		
II. Muni. wastewaters	28		2,000	1,500	3,000	8,000	1,000	1,000	38
Surface runoff	44	200,000				6,000	100	700	166
Indust. waste	1.7		100			5,000	<100		
III. Muni. wastewaters	470		61,000	37,000	59,000	154,000	14,000	12,000	290
Surface runoff	50	12,000				8,000	1,400	800	210
Indust. waste	100		2,800			18,000	1,300		
IV. Muni. wastewaters	510		169,000	106,000	160,000	311,000	35,000	9,000	112
V. Muni. wastewaters	196		28,000	21,000	36,000	113,000	7,400	5,500	48
Surface runoff	131	45,000				14,000	2,400	900	400
Indust. waste	144		12,800		6,000	43,000	800		9,500
VI. Muni. wastewaters	24		2,000	1,000	2,300	5,000	800	1,000	4
Surface runoff	13	17,000				1,000	500	300	180
VII. Muni. wastewaters	132		14,000	11,000	28,000	77,000	5,800	3,500	33
All Area									
Muni. wastewaters	1,380		278,000	179,000	291,000	675,000	65,000	33,000	530
Surface runoff	242	274,000				29,000	4,400	2,800	980
Indust. waste	251		16,000		6,000	78,000	2,200		

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Table II-90 (cont.)

Area	Ammonia Nitrogen	Organic Nitrogen	Total Nitrogen	Phosphate Phosphorus	Detergent (MBAS)	Cyanide (CN)	Phenols	Heat* (10 ⁹ kwh/yr)
I. Muni. wastewaters	400	150	560	183	97	2	2	
Surface runoff	34	15	73	14	0.5	<0.1	<0.1	
Indust. waste								
II. Muni. wastewaters	550	190	780	350	69	2	2	
Surface runoff	166	200	530	132	5	2	1	17
Indust. waste								
III. Muni. wastewaters	8,100	6,400	14,800	3,200	2,200	117	46	
Surface runoff	102	260	570	64	17	5	3	23
Indust. waste								
IV. Muni. wastewaters	41,000	13,700	55,000	7,300	3,500	58	1,620	
V. Muni. wastewaters	5,900	2,600	8,600	1,180	970	16	39	
Surface runoff	100	560	1,070	165	40	4	265	
Indust. waste	9,500		10,000				43	38
VI. Muni. wastewaters	350	123	590	240	95	2	3	
Surface runoff	37	52	270	35	3	0.1	0.1	9
VII. Muni. wastewaters	3,100	1,700	5,100	810	690	13	16	7
All Area								
Muni. wastewaters	59,400	24,800	84,500	13,300	7,600	210	1,730	
Surface runoff	440	1,090	2,510	410	66	11	269	
Indust. waste	9,500		10,000				43	94

*Cooling water flow not included in industrial waste flow rate.

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Table II-90 (cont.)

Area	Flow cu m/yr (10 ⁶)	Trace Metals										Chlorinated Hydrocarbons				
		Silver	Cad- mium	Cobalt	Chro- mium	Copper	Mer- cury	Nickel	Lead	Zinc	Iron	Manga- nese	Total DDT	Total PCB	Dieldrin	Total CHC
I. Muni. wastewaters	22															
Surface runoff	3.7	0.02	0.04	0.3	0.9	0.6		0.8	0.6	2	970	9	0.001	0.001	0.0001	0.002
II. Muni. wastewaters	28		0.3		1	1		1		4	8	2	0.002	0.003		0.005
Surface runoff	44	0.2	0.5	3.4	11	8		10	7	22	11,600	105	0.007	0.010	0.0007	0.018
III. Muni. wastewaters	470	1.1	25	3	148	190	2.1	147	31	330	660	16	0.088	0.57		0.86
Surface runoff	50	0.4	0.2	0.4	5	3		1	22	21	1,190	15	0.021	0.018	0.0098	0.049
IV. Muni. wastewaters	510	10.2	15.4		440	290	0.5	123	128	1,220	5,100	67	19	6		25
V. Muni. wastewaters	196	3.6	10.9		41	66	0.2	34	40	101	230	17	0.075	3		3.1
Surface runoff	131	0.5	0.4	0.9	7.3	6.0	0.05	4	57	52	11,900	39	0.088	0.214	0.02	0.322
VI. Muni. wastewaters	24															
Surface runoff	13	0.02	0.1	0.3	0.8	0.9	0.01	0.7	3	4	700	15	0.002	0.003	0.0007	0.006
VII. Muni. waste waters	132		2.5		19	20	0.1	8	12	22			0.022	0.11		0.14
TOTAL																
Muni. wastewaters	1,380	15	54	3.0	649	567	2.9	313	211	1,680	6,000	102	19.2	9.7		29
Surface runoff	242	1.1	1.2	5.3	25	18	0.06	17	90	101	26,000	183	0.119	0.246	0.031	0.396

*SOUTHERN CALIFORNIA COASTAL WATER PROJECT REPORT (TR 104), MARCH 1973.

are from Table II-90. "With a combined flow rate of 102 mgd or approximately 10% of the combined municipal waste water flow rate in Southern California, the estimated annual mass emission rates from discrete industrial waste dischargers in San Pedro Bay appear to be very low" (SCCWRP 1973).

The SCCWRP (1973) report points out that the total suspended solids, oil and grease, and chemical oxygen demand from industrial sources are significantly lower than those of similar types of waste discharged into the ocean from municipal sources. It should be noted however that all of the industrial waste is not discharged directly from their originating source but often into the municipal waste systems. The Los Angeles County Sanitation Districts Joint Water Pollution Control Plant receives the greatest quantity of this indirect industrial waste with Los Angeles Hyperion and Orange County Sanitation Districts Plants 1 and 2 receiving significant quantities of industrial wastes (Reed and Bakker, 1974).

Inputs of petroleum from terrestrial sources are mainly from municipal wastewaters, industrial wastewaters and surface runoff. A comparison of the estimated mass emission rates from these sources is given in Table II-91.

Table II-91 Sources of Oil and Grease/Petroleum
Discharged into the Southern California Marine Environment. (Storrs, 1973)

<u>Source</u>	<u>Mass Emission Rates (metric tons/yr)</u>	
	<u>Oil and Grease</u>	<u>Petroleum</u>
Municipal wastewaters	65,000	32,000
Industrial wastewaters	2,200	2,200
Runoff	4,400	?

As indicated in Table II-91 municipal wastewaters contribute large amounts of oil and grease (hexane - extractable), of which approximately 50 percent is petroleum. Young (1975) indicates that it has been tentatively estimated that such wastewaters may contribute up to 10 percent of the total known input of petroleum hydrocarbons to the world oceans.

Although industrial wastewaters are shown to discharge less petroleum than municipal dischargers, it is noted that petroleum industries contribute most of the petroleum to the municipal wastes.

From Storrs (1973) it is indicated that the petroleum refining capacity in Southern California is about 400 million barrels (bbls) per year, or about 10 percent of the total United States refinery capacity. Table II-92 shows the results of a recent survey of oil discharged to the Southern California coastal waters from the petroleum industry (SCCWRP, 1973).

Of the 2,200 metric tons per year discharged to the nearshore waters, approximately 80 percent is due to oil in refinery wastewaters. The remaining 20 percent is due to operations of both the onshore and offshore production facilities. In the Southern California area, the offshore production capacity is about 9.7 million bbls/yr. Thus, in terms of refinery capacity, the Southern California oil discharges are about 5 metric tons per million barrels (Storrs, 1973).

Table II-92

OIL DISCHARGES FROM THE PETROLEUM INDUSTRY
TO SOUTHERN CALIFORNIA COASTAL WATERS

<u>Wastewater Type</u>	<u>Wastewater Flow</u> <u>(cu m/s)</u>	<u>Mass Emission Rate</u> <u>((metric tons/yr)</u>
Oil field brines	1.75	380
Tanker and line ballast	0.35	65
Refinery wastewaters	4.72	1,740
Cooling tower bleedoff	0.03	<u>10</u> 2,200

The source of oil in runoff waters is from urban storm drainage, runoff from rural areas, and natural stream drainage. The percentage of petroleum in these waters is unknown.

Another source of oil is natural oil seeps. Young (1975) indicates that estimates of petroleum losses to the water column from the 50-60 known natural oil seeps between Point Conception and Huntington Beach appear to be relatively uncertain, although four seep sites at Coal Oil Point near Santa Barbara are reported to have lost the equivalent of 4000 metric tons/year during October, 1969. However, such seepage rates are reported to be quite variable. In comparison, estimates for the 1969 Santa Barbara oil spill range from 3000 to 113,000 metric tons, with an intermediate value of about 11,000 tons.

Chlorinated hydrocarbons and metals in sediments of the Southern California Bight have been shown by SCCWRP (1973) to be in higher concentrations around wastewater outfalls, with generally decreasing constituent concentrations with increased distance from the point source.

In a recent study by SCCWRP (1974), an area of 62 square kilometers on the Palos Verdes Shelf, was shown to have 200 (plus) metric tons of DDT in the upper 30 cm of the bottom sediment. This study was comprised of two sampling regions: Samples in Region A were collected by SCCWRP in June of 1972, and samples from Region B were collected by Andrew Soutar, Scripps Institution of Oceanography, in July 1972. The concentrations (mg/dry kg) of DDT compounds in the first two centimeters of sediments is shown in Figure II-108.

The estimated quantity of total DDT at various levels within the bottom sediment is shown in Table II-93. From Table II-93 it is seen that approximately 85% of the total DDT is found in the first 12 centimeters of bottom sediments.

The SCCWRP (1974) study concluded that the quantity of chlorinated hydrocarbons compounds found in the sediments off Palos Verdes constitute by far the largest known local benthic reservoir of chlorinated hydrocarbons along the Southern California coast.

Sediment core samples taken in the Santa Barbara Basin (SCCWRP, 1973) indicated that metals and chlorinated hydrocarbons concentration have been relatively constant over the last 100 or more years. Lead concentrations have increased over the last 20 years and mercury has increased from about 0.06 to 0.15 mg/dry kg over approximately the last 100 years.

Fifteen power generating plants along the Southern California coast (SCCWRP 1973) use approximately 38.6×10^6 cu. m/day (10.2 billion gals.) of ocean water for cooling purposes. The cooling water is raised an average of 10.50° C (Table II-94) contributing the only single large-scale source of thermal pollution to the ocean waters of the Southern California Bight.

Figure II-108 Sampling region and concentration of total DDT (mg/dry kg) in surface sediments (0 to 2 cm) off Palos Verdes.

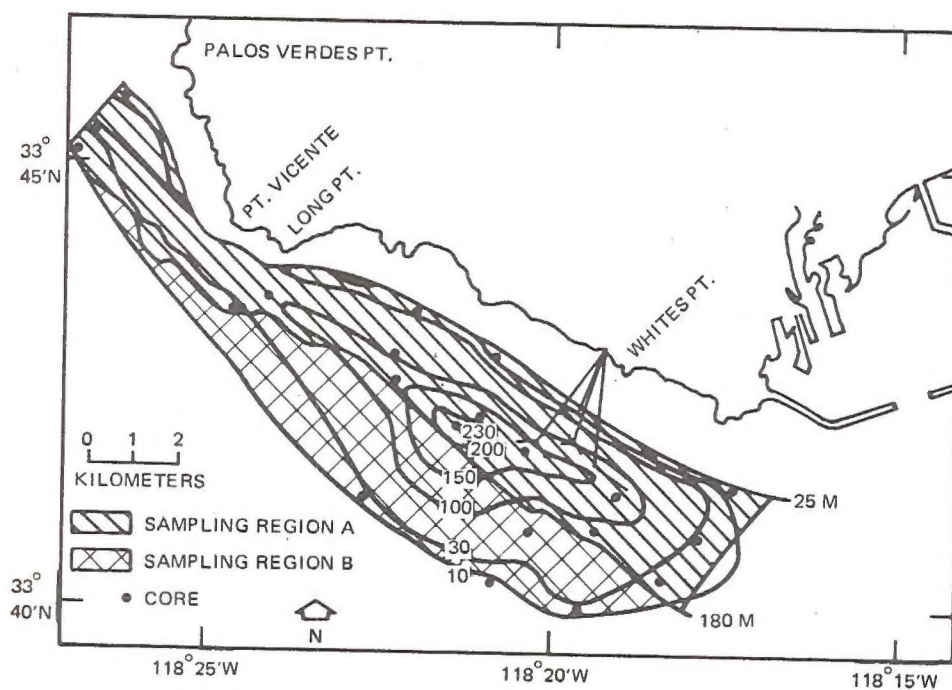


Table II-93 Total DDT (metric tons) in Palos Verdes bottom sediments, 1972.

Depth (cm)	Region A, 37 sq km	Region B, 25 sq km	Total, 62 sq km
0 - 12	136	52	188
12 - 20	24	5	29
20 - 30	1	0.1	1
Total	161	57	218

Both the Figure II-108 and Table II-93 were from SCCWRP, 1974.

Table II-94 From: SCCWRP Report TR 104 (March, 1973)

THERMAL DISCHARGES AT POWER GENERATING STATIONS
IN THE SOUTHERN CALIFORNIA COASTAL AREA AS OF 1970-71^a

Fuel STATION- Location	Plant Operation			Estimated Waste Heat to Cooling Water ^d				Estimated Cooling Water Flow ^d		
	1	2	3	4	5	6 Plant Waste Heat, H		7	8 Cooling Water Flow, R	
	Capacity, Mw _e (mw)	Load Factor, F (%)	Overall Efficiency, E (%)	Waste Heat per unit of Electrical Output, Q	Waste Heat to Cooling Water per Unit Output, Q _w	6A Maximum, H _{max} (10 ⁶ kw)	6B Average, H _{avg} (10 ⁶ kw)	Normal Average Temp Rise, T (°C)	8A Maximum, R _{max} (10 ⁶ cu m/day)	8B Annual, R _{avg} (10 ⁸ cu m/year)
FOSSIL-FUEL TYPE										
<u>L.A. Dept. of Water and Power</u>										
P1 Harbor, Wilmington	445	14	25	3.00	2.55	1.1	0.2	11	2.1	1.1
P2 Haynes, Seal Beach	1,625	60	36	1.78	1.51	2.5	1.5	10.5	4.8	10.5
P3 Scattergood, Playa del Rey	350	59	34	1.65	1.65	0.5	0.3	10	1.2	2.5
Subtotal	2,420					4.1	2.0		8.1	14.1
<u>Southern California Edison Co.</u>										
P4 Alamitos, Seal Beach	1,950	58	36	1.78	1.51	2.9	1.7	11	5.5	11.6
P5 El Segundo, El Segundo	1,020	50	35	1.86	1.58	1.6	0.8	12	2.7	5.0
P6 Huntington, Huntington Beach	990	65	35	1.86	1.58	1.6	1.0	12	2.8	6.5
P7 Long Beach, Long Beach ^b	210	20	25	3.00	2.55	0.5	0.1	10.5	1.0	0.8
P8 Mandalay, Oxnard	430	73	36	1.78	1.51	0.6	0.5	11	1.2	3.2
P9 Redondo, Redondo Beach	1,600	52	33	2.03	1.72	2.8	1.4	11	5.1	9.8
P10 Ormond, Ormond Beach	1,580	55	34	1.94	1.65	2.6	1.4	10.5	5.1	10.2
Subtotal	7,780					12.6	6.9		23.4	47.1
<u>San Diego Gas and Electric Co.^b</u>										
P11 Encino, Carlsbad	345	55	34	1.94	1.55	0.5	0.3	10.5	1.1	2.2
P12 Silver Gate, San Diego Bay	235	55	34	1.94	1.65	0.4	0.2	7	1.1	2.2
P13 South Bay, San Diego Bay	530	55	34	1.94	1.65	0.9	0.5	7	2.5	5.0
P14 Station "B," San Diego Bay	95	55	34	1.94	1.65	0.2	0.1	7	0.5	0.9
Subtotal	1,205					2.0	1.1		5.2	10.3
Total, Fossil-Fuel Type	11,405					18.7	10.0			7.5
Weighted Mean ^c		55	34	1.94	1.65			10.5		
NUCLEAR										
P15 San Onofre, San Clemente	450	80	32	2.12	2.02	0.9	0.7	10	1.9	5.5
TOTAL	11,855					19.6	10.7		38.6	77.0

a. Station operating data provided by power companies, except as noted in Note b below.

b. Estimated values for the year 1971.

c. All mean values are weighted by plant capacity.

d. Calculations: (i) Column (4): $Q = (1 - E)/E$

(ii) Column (5): Assume 15% of heat wastage lost through stack for fossil-fuel-type plant; 5% for nuclear power plant.

(iii) Column (6A): $H_{max} = (MW_e) \times (Q_w) \times 10^3$

(iv) Column (6B): $H_{avg} = (H_{max}) \times F$

(v) Column (8A): $R_{max} = (H_{max}) \times 20.7/(T)$

(vi) Column (8B): $R_{avg} = (R_{max}) \times (1) \times 365$

Terrestrial surface runoff constitutes the third and last "discrete" (SCCWRP 1973) source of pollution in the Bight area. There are 200-300 major rivers, streams and storm drains (SCCWRP 1973) which yearly introduce a wide spectrum of solids, trace metals, chemicals, organic nutrients and hydrocarbons into the marine environment (Table II-95). Surface runoff is seasonal, being the greatest during winter months.

Table II-96 compares the various pollutant factors of municipal waste water, surface runoffs, and industrial water, using several different parameters (total suspended solids, oil and grease, trace metals, 5 day BOD). With the exception of silt and the trace metals iron and manganese, municipal waste waters are the largest single contributors of pollutants.

There are sixteen documented ocean dumping sites within the Southern California Bight (Smith & Brown 1971, Brown 1970, COMTHIRDFLT 1973). These sites were used for disposal of industrial, military and commercial wastes until 1972 (dumping moratorium U.S. Dept. of Navy 1971), when the enactment of the Marine Protection, Research, and Sanctuaries Act of 1972 prohibited ocean dumping.

The disposed material was composed of: industrial chemicals and solvents, aerospace industry waste, petroleum refinery wastes, obsolete or unserviceable military munitions, toxic chemical ammunition, nuclear industry and laboratory radioactive waste materials, waste acid, vessel refuse and garbage.

Graphic 2 shows 14 ocean dumping areas documented by Brown (1970) and two United States Navy emergency aircraft ordinance jettison areas. The aircraft jettison ordinance disposal areas, numbers 15 and 16, are located at: primary jettison area (#16) 33° N Lat - 117° 48' W Long and secondary jettison area (15) 33° N Lat. - 118° 15' W Long. These

Table II-95 From: SCCWRP Report (March, 1973)
SUMMARY OF STORM WATER AND DRY WEATHER FLOW SAMPLING EFFORT, 1971-72

LOW FLOW DURING EFFORT, 1971-72

Area	Stream	Sample Designation	Storm Flow		Sample Designation	Dry Weather Flow	
			Estimated Flow (1,000 cu m/yr)			Date Collected (1972)	Estimated Flow (1,000 cu m/yr)
			Sampled	Not Sampled			
I	Santa Barbara Group			2,500			1,200
II	Ventura River			3,000	R11	6 Apr	11,700
	Santa Clara River	R1	26,000		R12	2 May	- *
	Calleguas Creek			700	R13	29 Mar	2,700
III	Malibu Creek			3,400			-
	Pico Drain			1,200	R14	11 Apr	3,600
	Ballona Creek	R2	26,000		R15	28 Mar	15,700
V	Dominguez Channel			5,300	R16	28 Mar	5,400
	Los Angeles River	R3	48,000		R17	28 Mar	20,000
	San Gabriel River			10,300	R18	28 Mar	300
	Coyote Creek			27,000	R19	2 May	4,000
	Santa Ana River	R4	1,800	8,600			-
VI	San Diego River			2,500	R20	2 May	8,000
	San Juan Creek			200	R21	2 May	2,100
APPROX. TOTAL			102,000	65,000			75,000

*Dry weather flow diverted by percolation.

Table II-96 From: SCCWRP Report (March, 1973)

CONSTITUENT MASS EMISSION RATES (M TONS/YR) FROM SURFACE
RUNOFF IN SOUTHERN CALIFORNIA, 1971-72

Stream	Flow (10 ⁶ cu m/yr)	Silt	Total Organic Carbon*	Chemical Oxygen Demand	Oil And Grease	Dissolved Silica (SiO ₂)	Nitrate Nitrogen*	Ammonia Nitrogen	Organic Nitrogen	Total Nitrogen	Phosphate Phos- phorus*	Detergent (MBAS)	Cyanide (CN)	Phenols
Santa Barbara Co. Storm	2.5	200	200	100	<50	50	16	23	10	49	9	0.4	<0.1	<0.1
Dry Weather	1.2	100	100	<100	<50	<50	8	11	5	24	4	0.2	<0.1	<0.1
Ventura R. Storm	3	200	200	100	<50	50	20	27	12	59	11	0.4	<0.1	<0.1
Dry Weather	11.7	700	900	500	<50	200	75	107	46	230	43	1.6	0.1	<0.1
Santa Clara R. Storm	26	199,000	2,800	4,800	50	300	63	11	132	206	64	2.6	2.4	0.8
Calleguas Cr. Storm	0.7	<100	<100	100	50	<50	2	4	2	8	3	0.1	<0.1	<0.1
Dry Weather	2.7	100	100	300	50	80	7	17	9	33	11	0.2	0.1	<0.1
Malibu Cr. Storm	3.4	1,000	300	400	50	<50	15	4	17	36	5	1.0	0.1	0.3
Pico Drain Storm	1.2	500	100	300	<50	<50	7	2	8	17	2	0.5	0.2	0.1
Dry Weather	3.6	200	100	200	180	100	9	1	9	19	7	1.2	<0.1	<0.1
Ballona Cr. Storm	26	10,000	2,800	6,600	600	250	151	42	180	370	36	10.3	4.1	2.3
Dry Weather	15.7	800	200	500	530	420	30	55	49	134	14	4.1	0.1	<0.1
Dominguez Ch. Storm	5.3	100	100	1,000	180	50	1	<1	13	14	2	3.8	<0.1	127
Dry Weather	5.4	100	100	1,000	190	50	1	<1	13	14	2	3.9	<0.1	130
Los Angeles R. Storm	48	14,000	3,600	5,700	590	50	204	53	242	500	72	14.5	1.9	4
Dry Weather	20	1,200	200	700	790	36	14	<1	67	81	13	3.2	0.2	<0.1
San Gabriel R. Storm	10.3	3,000	800	1,300	130	110	44	11	52	107	16	3.1	0.4	1
Dry Weather	0.3	<100	<100	<100	<50	50	1	3	1	5	3	0.1	<0.1	<0.1
Coyote Cr. Storm	27	8,000	2,000	3,200	330	290	110	30	140	280	40	8.1	1.1	2
Dry Weather	4	100	100	200	140	50	12	<1	11	23	1	3.0	0.1	<0.1
Santa Ana R. Storm	10.4	18,000	600	600	70	50	15	2	27	44	16	0.6	0.3	1
San Diego Cr. Storm	2.5	4,000	100	300	90	50	42	9	12	63	8	0.7	<0.1	<0.1
Dry Weather	8	13,000	400	900	290	170	133	28	37	198	27	2.2	<0.1	<0.1
San Juan Cr. Storm	0.2	<100	<100	<100	<50	<50	1	<1	<1	1	<1	<0.1	<0.1	<0.1
Dry Weather	2.1	<100	<100	<100	60	50	5	1	<3	8	<1	0.3	<0.1	<0.1
Total Storm	167	258,000	13,000	24,500	2,100	1,330	690	218	840	1,750	283	46	10.4	139
Dry Weather	75	16,000	2,200	4,400	2,300	1,510	290	224	250	760	126	20	0.6	130
TOTAL	242	274,000	15,200	28,900	4,400	2,840	980	442	1,090	2,510	409	66	11.0	269

*Combined mass emission rates of soluble and suspended silt fractions

two areas are located between the northern tip of San Clemente Island and Solano Beach on the California coast, in 900 meters of water.

Depths of the other disposal sites are stated in Table G2-1 in Appendix 10G.2. are located in water over 400 meters deep (exceptions are #8-119 meters and #13-366 meters). Table G2-2 in Appendix 10G.2. (Brown, 1971) is a summary of wastes dumped into the Southern California Bight 1931-71 through ocean dumping programs. Brown states that environmental monitoring of dumping operations is non-existing and that studies to determine the environmental effect of this type of ocean pollutant are non-existent.

Ocean dumping under the 1972 Act is regulated by permits issued by the United States Environmental Protection Agency. At the present time there is only one such permit in use (application #0073-02); this is to H-10 Water Taxi Company Ltd., San Pedro, California for foreign vessel refuse disposal. This permit expires in January of 1975 and is not expected to be renewed since the Port of Los Angeles and/or Long Beach anticipate other disposal methods for foreign vessel generated waste material.

Aerial pollution of the Southern California Bight is not well documented except for some rain fall-out studies by Lazarus, et al. (SCCWRP 1973) conducted on Catalina Island from September 1966 to January 1967 and extrapolated for the whole Bight Area. The SCCWRP report cites several other studies of this sort, but these are land study areas projected for the marine environment.

Dredging is a process commonly used along the entire length of the Pacific Coast to keep harbors open and to increase the depth of navigable channels. Dredging produces a large quantity of spoil which is

potentially dangerous to the environment since its redeposition can adversely effect the biota. Silt and Clay are the primary deleterious grain sizes.

Special areas are designated for the dumping of dredge spoil. Spoil with silt and clay components is best disposed of on land. However, this is not always possible. There are a number of offshore sites designated as acceptable for dredge spoil disposal by the Environmental Protection Agency. The sites for Southern California are:

- | | | |
|-------|-------------------------|--|
| LA 1. | Port Hueneme-100 Fathom | 34°05'00"N, 119°14'00"W |
| | Distance: | 3.7 nautical miles from shore |
| | Depth: | 200 fathoms |
| | Size: | 1000 yard radius |
| LA 2. | Los Angeles-100 Fathom | 33°37'06"N, 118°17'24"W |
| | Distance: | 5.3 nautical miles from shore (5.8
nautical miles from mouth of Los Angeles
Harbor). |
| | Depth: | 100 fathoms |
| | Size: | 1000 yard radius |
| LA 3. | Newport Beach | 33°31'42"N, 117°54'48"W |
| | Distance: | 4.0 nautical miles from harbor mouth |
| | Depth: | 250 fathoms |
| | Size: | 1000 yard radius |
| LA 4. | San Diego - Point Loma | 32°35'00"N, 117°17'30"W |
| | Distance: | 5.4 nautical miles from Point Loma |
| | Depth: | 45 fathoms |
| | Size: | 1000 yard radius |
| LA 5. | San Diego-100 Fathom | 32°36'50"N, 117°20'40"W |
| | Distance: | 7.7 nautical miles from shore |
| | Depth: | 100 fathoms |
| | Size: | 1000 yard radius |

The Environmental Protection Agency's Dredge Disposal Criteria is used in the evaluation of dredge spoil as to whether or not dredge spoil is considered polluted or nonpolluted. Spoil that is within the nonpolluted EPA criteria is felt to have a non-lethal affect on the marine biota.

I. Historical and Projected Economic Growth

A discussion of impacts for this section may be found in Section III.J.2.

1. Population

As of July 1, 1974, California had an estimated population of 20,933,000 reflecting a one percent increase as compared to a year earlier. The two fastest growing metropolitan areas in total actual gain were Orange and San Diego counties, with respective increases in population of 50,600 and 40,800. In 1974 Los Angeles County was the only Standard Metropolitan Statistical Area in California to show a decrease with approximately 8,900 fewer people than in the same period in 1973 (Table II-96).

Our study area, Southern California's coastal counties from Santa Barbara to San Diego, had an estimated population of 10,833,200 by July 1, 1974. This represents slightly more than one-half the population of the entire state on less than nine percent of the land area. Southern California experienced approximately a one percent increase in population in 1973. This is the same rate of growth as experienced by California and the United States as a whole (Table II-96 and II-97).

During the century following 1860, California's population doubled five times, or once each twenty years. In the period 1960 to 1970, California's population increased 27 percent, which was more than double the average growth rate for the United States (Table II-98).

The unusual rate of growth which California experienced through 1965 is no longer possible not only because of the very size of the base, but also because in absolute terms net migration and the number of births has declined substantially. In the past five years the

Table II-96

TOTAL POPULATION OF SOUTHERN CALIFORNIA COASTAL COUNTIES

JULY 1, 1971, JULY 1, 1972, JULY 1, 1973 and JULY 1, 1974
WITH ANNUAL PERCENT CHANGE

County	July 1, 1971 (Revised)	July 1, 1972 (Revised)	July 1, 1973 (Revised)	July 1, 1974 (Provisional)	Annual Percent Change 71-72	72-73	73-74
Los Angeles-----	7,058,700	7,015,100	6,970,100	6,961,200	-0.6	-0.6	-0.1
San Diego-----	1,390,600	1,432,100	1,469,100	1,509,900	3.0	2.6	2.8
Orange-----	1,481,600	1,532,000	1,605,700	1,656,300	3.4	4.8	3.2
Ventura-----	391,700	405,900	417,900	426,000	3.6	3.0	1.9
Santa Barbara-----	269,700	271,500	276,100	279,800	0.7	1.7	1.3
Total Southern California---	10,592,300	10,656,600	10,738,900	10,833,200	0.6	0.8	0.9
State Total-----	20,311,000	20,518,000	20,730,000	20,933,000	1.0	1.0	1.0

Note: See Table II-4 for components of these population changes.

Source: State of California, Department of Finance, Population Research Unit.

Table II-97

ESTIMATED POPULATION OF CALIFORNIA AND THE
UNITED STATES, 1960-73

Year (July 1)	United States ^a	Annual change		Annual change	
		Number	Percent	California	Number Percent
Total ^b					
1960.....	179,979,000	---	---	15,863,000	---
1961.....	182,992,000	3,013,000	1.7	16,366,000	503,000 3.2
1962.....	185,771,000	2,779,000	1.5	16,905,000	539,000 3.3
1963.....	188,483,000	2,712,000	1.5	17,518,000	613,000 3.6
1964.....	191,141,000	2,658,000	1.4	18,021,000	503,000 2.9
1965.....	193,526,000	2,385,000	1.2	18,491,000	470,000 2.6
1966.....	195,576,000	2,050,000	1.1	18,851,000	360,000 1.9
1967.....	197,457,000	1,881,000	1.0	19,234,000	383,000 2.0
1968.....	199,399,000	1,942,000	1.0	19,513,000	279,000 1.5
1969.....	201,385,000	1,986,000	1.0	19,819,000	306,000 1.6
1970.....	203,810,000	2,425,000	1.2	20,027,000	208,000 1.0
1971.....	206,212,000	2,402,000	1.2	20,296,000	269,000 1.3
1972.....	208,230,000	2,018,000	1.0	20,518,000	222,000 1.1
1973.....	209,851,000	1,621,000	0.8	20,741,000	223,000 1.1
Civilian					
1960.....	178,140,000	---	---	15,567,000	---
1961.....	181,143,000	3,003,000	1.7	16,076,000	509,000 3.3
1962.....	183,677,000	2,534,000	1.4	16,598,000	522,000 3.2
1963.....	186,493,000	2,816,000	1.5	17,198,000	600,000 3.6
1964.....	189,141,000	2,648,000	1.4	17,714,000	516,000 3.0

Table II-97 (Continued)

Year (July 1)	United States ^a	Annual change		California	Annual change	
		Number	Percent		Number	Percent
1965.....	191,605,000	2,464,000	1.3	18,182,000	468,000	2.6
1966.....	193,420,000	1,815,000	0.9	18,499,000	317,000	1.7
1967.....	195,264,000	1,814,000	1.0	18,871,000	372,000	2.0
1968.....	197,113,000	1,849,000	0.9	19,147,000	276,000	1.5
1969.....	199,145,000	2,032,000	1.0	19,458,000	311,000	1.6
1970.....	201,722,000	2,577,000	1.3	19,690,000	232,000	1.2
1971.....	204,250,000	2,528,000	1.1	19,972,000	282,000	1.4
1972.....	206,457,000	2,207,000	1.1	20,218,000	246,000	1.2
1973.....	208,094,000	1,637,000	0.8	20,441,000	223,000	1.1

^a Includes Alaska and Hawaii.

^b Includes members of the Armed Forces stationed in the area.

Source: U. S. Bureau of the Census, Current Population Reports, Series P-25, No. 504 (August 1973), and Department of Finance estimates.

Department of Finance
Budget Division
Population Research Unit

Table II-98

POPULATION^a AND PERCENT INCREASE IN POPULATION BY
DECADE, CALIFORNIA, PACIFIC DIVISION, AND THE
UNITED STATES, 1970

	1970
Population ^a	
California.....	19,953,134
Pacific division ^b	26,525,774
United States.....	203,184,772
Percent change	
California.....	27.0
Pacific division.....	25.1
United States.....	13.3

^a Includes Armed Forces stationed in the state or states.

^b Includes the states of California, Oregon, Washington, Alaska, and Hawaii.

Source: U. S. Bureau of the Census, U. S. Census of Population, 1960.
Final Report PC(1)-1A; 1970 Census of Population, Advance Report
PC(V1)-6 and news releases.

Department of Finance
Budget Division
Population Research Unit

level of migration has averaged about 207 per day more arrivals than departures. This is substantially below the "thousand per day" which was commonplace a decade ago.

The greatest stimulus to California's economic and population growth came between the years 1950-1960 as a result of new highs in defense spending. The impact of defense spending effected major changes in California's growth patterns. Some urban centers have grown more rapidly than otherwise would have been the case. This was most obvious in the areas around Los Angeles, San Diego, San Jose and Orange Counties. Defense spending stimulated the expansion of the manufacturing sector of the economy during the 50's which created new employment opportunities and the resultant population expansion. Simply stated "people tend to migrate to areas which offer employment opportunities."

The pressures that have been put on California's coastal zone as an attractive location for industrial and military developments has also brought heavy urban development; consequently the heavy population centers are to be found here. The heavy influx of people combined with a search for "cheap land" had helped lead to the urban sprawl we experience today.

Coastal areas are expected to experience continued growth by recent projections, with the exception of the Los Angeles County area. Projections for the Los Angeles area vary from an increase in population to a shallow decline. Some of the basic reasons given for a decline are pollution, crowded conditions, drop in birth expectations and decrease in net in-migration (Table II-99).

Table II-99

COMPONENTS OF POPULATION CHANGE
5 SOUTHERN CALIFORNIA COASTAL COUNTIES
SELECTED YEARS 1961 - 1974

(AS OF JULY 1)

		Los Angeles County	San Diego County	Orange County	Ventura County	Santa Barbara County	Total
1961	Total Change	148,000	31,200	69,700	14,900	16,400	280,200
	Natural Increase	85,900	19,400	15,300	4,100	3,200	127,900
	Net in-Migration	54,400	15,800	51,800	11,300	12,900	146,200
	Net Military	7,700	-4,000	2,600	-500	300	6,100
1965	Total Change	106,100	19,800	79,400	24,600	7,900	237,800
	Natural Increase	76,200	14,900	17,700	4,900	3,300	117,000
	Net in-Migration	26,300	2,100	62,300	20,800	4,400	115,900
	Net Military	3,600	2,800	-600	-1,100	200	4,900
1970	Total Change	15,400	10,300	48,200	9,400	1,300	84,600
	Natural Increase	69,400	14,500	17,400	5,100	2,500	108,900
	Net in-Migration	-69,000	28,500	28,700	8,200	-800	-4,400
	Net Military	15,000	-32,700	2,100	-3,900	-400	-19,900
1971	Total Change	13,500	32,100	48,700	10,500	5,000	109,800
	Natural Increase	63,764	13,572	17,202	5,008	2,293	101,839
	Net in-Migration	-59,397	18,831	31,677	6,229	2,786	126
	Net Military	9,133	-303	-179	-737	-79	7,835
1972	Total Change	-43,600	41,500	50,400	14,200	1,800	64,300
	Natural Increase	46,670	11,465	13,989	4,338	1,849	78,311
	Net in-Migration	-100,616	36,483	35,340	8,293	-40	-20,540
	Net Military	10,346	-6,448	1,071	1,569	-9	6,529

Table II-99 (Continued)

		Los Angeles County	San Diego County	Orange County	Ventura County	Santa Barbara County	Total
1973	Total Change	-45,000	37,000	73,700	12,000	4,600	82,300
	Natural Increase	43,779	10,686	13,852	4,066	1,517	73,900
	Net in-Migration	-92,662	34,817	58,764	7,131	3,473	11,523
	Net Military	3,883	-8,503	1,084	803	-390	-3,123
1974	Total Change	-8,900	40,800	50,600	8,100	3,700	94,300
	Natural Increase	39,557	10,096	13,273	3,997	1,229	68,152
	Net in-Migration	-37,868	27,862	37,796	5,852	2,540	36,182
	Net Military	-10,589	2,842	-469	-1,749	-69	-10,034

Source: State of California, Department of Finance, Population Research Unit

In Southern California the reasons for the changing rate of migration have been frequently debated. Cited among them are problems of congestion, pollution and earthquakes. The sheer size of the area creates problems of urban sprawl and related considerations which may weigh heavily on personal decisions to move to Southern California, and on the decisions of some Californians to move elsewhere. It may be true that Southern California has a moderate year-round temperature, which makes it an attractive place to live, but few people select their place of residence on the basis of climate alone.

One prerequisite for a high rate of immigration is a vibrant and healthy economy. Thus, the immigration trends of the latter 1950's and early 1960's were sustained by the aerospace boom. Conversely, the major cutbacks in NASA, Department of Defense, and other high-technology industries, undertaken in the last few years have deterred new migrants from moving into the area and induced some Southern Californians to leave. This latter trend, moreover, coincided in part with a period of economic recession, which always has a negative impact on immigration rates, as in 1953-54, 1957-58 and 1970.

Within our five county study area, three of the counties, Los Angeles, Orange and San Diego, are the most populous in the state in that order. Between 1960 - 1970 the population density per square mile or total population in Orange County almost doubled (Table II-100). Almost 77 percent of this growth was due to immigration which compares with 50 percent for the state as a whole (Table II-101). Much of this growth can be attributed to a significant increase in new business in the county which included an influx of some Los Angeles firms moving

Table II-100
POPULATION PER SQUARE MILE OF
SOUTHERN CALIFORNIA COASTAL COUNTIES
SELECTED YEARS

County	Land Area in Square Miles	Population Density Per Square Mile			Percent Change	
		1960	1970	1973	1970 1960	1973 1960
Los Angeles	4,069	1492	1731	1713	16	15
Orange	782	920	1832	2053	99	123
San Diego	4,261	246	319	345	30	40
Ventura	1,863	109	205	229	88	110
Santa Barbara	2,737	63	97	102	54	62
Southern California ^{1/}	13,712	599	764	783	28	31
California	156,361	101	128	133	27	32

From: Statistical Abstract of California (1973).

^{1/} Total of the five coastal counties.

Table II-101

SOUTHERN CALIFORNIA COASTAL COUNTIES
ESTIMATES OF THE COMPONENTS OF TOTAL POPULATION
CHANGE--JULY 1, 1960 TO JULY 1, 1970

County	Population		Change, 1960-1970		Components of change	
	July 1, 1960	July 1, 1970	Number	Percent	Natural increase	Net migration ^{1/}
Los Angeles-----	6,071,900	7,044,500	972,600	16.0	730,700	241,900
San Diego-----	1,049,000	1,358,500	309,500	29.5	152,300	157,200
Orange-----	719,500	1,432,900	713,400	99.2	164,600	548,800
Ventura-----	203,100	381,200	178,100	87.7	46,100	132,000
Santa Barbara-----	173,600	264,700	91,100	52.5	30,400	60,700
Total, Southern California-----	8,217,100	10,481,800	2,264,700	27.6	1,124,100	1,140,600
State Total-----	15,863,000	20,027,000	4,164,000	26.2	2,082,000	2,082,000

^{1/} Includes changes in the military population stationed in the county and the State.

Source: State of California, Department of Finance, Population Research Unit.

across the county line. In total almost 90 percent of the county's population lives in the lowlands in the western half of Orange County. The heavy population centers are located adjacent to the Los Angeles County line and the area is becoming a suburb or bedroom community to Los Angeles proper. Pointing up this fact is that while Los Angeles is losing population, civilian employment is on the upswing. Ventura County's population increase during this same ten year period was almost as dramatic, reflecting approximately a 90 percent increase of which 74 percent was attributed to an influx of new people. Much of the growth took place in the eastern portion of the county where approximately one-half of the work force commute to Los Angeles daily. This is an extension of the trend towards urban sprawl and away from the inner core city.

In San Diego County the 1960 to 1970 growth was approximately 30 percent. The components of change in this area most nearly equaled the state as compared to any other county in our study area in that the increase due to migration and natural increase was about even. The lack of migration into this county was the major factor limiting growth during this period. Since that time the picture has changed, as immigration is up sharply and the growth closely resembles the pattern in Orange and Ventura Counties. Much of this increase can be attributed to new business in the tourism and recreation industry which has more than offset losses between 1969-1972 in the manufacturing sector of the economy.

During this past decade, Santa Barbara County reflected a better than 50 percent growth of which two-thirds was due to new people mov-

ing into the area. The county is presently striving to control its growth and it appears to have achieved some success in this area, although 70 percent of new growth can still be attributed to immigration.

Los Angeles County with a 16 percent increase in population between 1960-70 recorded the smallest percentage gain in the five county area, but because of the size of the base the total increase was almost one million people. Compared to the other counties the percentage increase is small, but to put it in the proper perspective, it is still greater than the national increase for this period of 13 percent. Migration accounted for only 25 percent of the increase which was the lowest for our study area. There were several factors responsible for this slow rate of growth compared to earlier periods. Among them were cutbacks in the aerospace industry, slow economic growth, and finally, the recession and earthquake in 1970. This trend continued until 1972 when Los Angeles County turned in a negative growth rate with the loss of approximately 43,600 people. During this period (July 1971-72) more than 100,000 people moved out of the county than in. 1973 was almost a repeat of 1972 with the total population showing a decline which was coupled with a heavy out migration. Between July 1973-74 a distinct slowing in this trend was noted. The county still turned in a negative growth but it was much smaller than the previous two years. The population loss between 1973 and 1974 can be mainly attributed to a loss in military personnel such as at Fort MacArthur, etc.

In summary, Southern California coastal counties experienced exceptional population growth during the past several decades. A dis-

tinct slowing was apparent in the latter part of the 1960's. As the decade progressed, it became evident that a decline in the rate of population growth was taking place and this trend has continued to the present time. The increases in three of the counties (Orange, San Diego and Ventura) when examined separately is two to three times greater than the national percentage increase, but when these areas are lumped with Los Angeles County the negative growth factor and the sheer size of the base pulls the area increase (including Santa Barbara County) down to the level of the national population increase (Table II-96, II-97).

Southern California's image is changing. Potential newcomers are reading about congestion, pollution, earthquakes and unemployment and some are changing their thinking. There are, however, some positive aspects of a slower growth rate. Ironically, one of the impediments to future growth of this area has been the rapid rate of economic expansion that occurred over the past two or three decades. It was very difficult for planning authorities actually to plan ahead. Nearly all they could do was attempt to keep up with the rapid population and economic growth of the area. With a more orderly rate of expansion, it would appear that this area might now be in a better position to plan for the future.

Los Angeles County is beginning to show some strength. The population appears to be leveling and the number of people leaving the area is showing some slack. Generally, the Southern California coastal area is beginning to exhibit signs of a more stable growth pattern.

In forecasting projections of population for an area, there are two important components which must be analyzed: 1) natural increase; and 2) migration. Population at any given time is necessarily a function of the births and deaths in the study area (natural increase), plus the difference between incoming and outgoing persons (i.e., migration). Natural increase is a much easier component to evaluate than migration. This encompasses such things as marriages, birth, mortality and fertility rates. The characteristics of a community by age group is critical when making an analysis. A concentration of young people, such as in Ventura County, will probably have the effect of raising the fertility and birth rates and lowering the mortality rate (barring major disasters and catastrophes). The opposite would be true for Santa Barbara County where the average age is considerably higher. Migration rates are much more difficult to project. The most promising possibility for an accurate forecast in this area would be to consider variables such as trends in employment, labor force participation, wages and salaries, and factors related to intracounty and intrastate migration. In simple terms economic and climatic conditions are the major variables. Since a great deal of uncertainty is encountered in this area, differences will be noted from one projection to the next depending upon interpretation of available statistics and who is conducting the forecast. Additionally, these differences will be carried over to forecasting of business and agriculture as well. Differences may also be noted on current and historic population figures between different sources. Some of this can be accounted for by time frame (some are mid-year, others end-of-year figures). Another

dependent factor is whether or not the data is preliminary or revised figures. This in itself can often be responsible for marked changes in estimates even from the same source.

It should be pointed out that population projections are not normally predictions of things to come, but are a set of population figures that may reasonably be expected if a certain set of conditions are met. These conditions which include migration and fertility levels are based on current as well as historic performance. In Table II-102 there are four projections, one a baseline and three alternate projections based on various fertility levels of 2.1 to 2.8 and immigration annually of between zero and 150,000. These levels are thought to be reasonable but do not represent possible extremes. In California between 1971-73 natural civilian increase has varied between 132,000 - 184,000 while net civilian immigration has fluctuated between 46,000 - 79,000. Other factors were considered such as changes due to military, etc. It should be noted that this projection is based on a demographic model and does not include assumptions for either social, economic or political changes.

For comparison of population and business projections, the OBERS projections for Southern California's Standard Metropolitan Statistical Areas (SMSA) are attached (APPENDIX A).

A population study, by county, describing community characteristics follows.

Table II-102

BASELINE AND ALTERNATIVE PROJECTIONS
TOTAL POPULATION OF SOUTHERN CALIFORNIA COASTAL COUNTIES,
PROJECTED 1975-2020 WITH ASSUMED MILITARY POPULATIONS

July 1, 1975

County	BASELINE	ALTERNATE PROJECTIONS			Assumed Military
	Series D-100 ¹	Series E-0	Series D-150	Series C-150	
Los Angeles.....	6,924,500	6,868,900	6,924,500	6,936,600	24,200
Orange.....	1,712,000	1,698,900	1,712,000	1,714,900	11,100
San Diego.....	1,573,100	1,560,700	1,573,100	1,575,800	97,400
Ventura.....	446,200	444,000	446,200	447,000	6,000
Santa Barbara.....	283,300	282,100	283,300	283,700	5,500
Southern California ² ..	10,939,100	10,854,600	10,939,100	10,958,000	144,200
The State.....	21,206,000	21,075,000	21,206,000	21,242,000	275,000

July 1, 1980

County	BASELINE	ALTERNATE PROJECTIONS			Assumed Military
	Series D-100	Series E-0	Series D-150	Series C-150	
Los Angeles.....	6,963,200	6,674,500	6,977,900	7,043,300	24,200
Orange.....	1,970,500	1,900,500	1,980,600	1,997,100	11,100
San Diego.....	1,801,300	1,750,600	1,821,700	1,837,000	97,400
Ventura.....	523,300	497,700	527,400	532,000	6,000
Santa Barbara.....	305,800	298,900	307,400	309,800	5,500
Southern California....	11,564,100	11,122,200	11,615,000	11,719,200	144,200
The State.....	22,659,000	21,933,000	22,760,000	22,955,000	275,000

Table II-102 (Cont.)

July 1, 1985

County	BASELINE		ALTERNATE PROJECTIONS		Assumed Military
	Series D-100	Series E-0	Series D-150	Series C-150	
Los Angeles.....	7,122,900	6,574,700	7,155,600	7,294,200	24,200
Orange.....	2,233,900	2,063,600	2,280,600	2,318,900	11,100
San Diego.....	2,022,400	1,905,800	2,105,800	2,141,700	97,400
Ventura.....	612,100	550,200	626,800	638,000	6,000
Santa Barbara.....	333,700	313,600	336,900	342,300	5,500
Southern California....	12,325,000	11,407,900	12,505,700	12,735,100	144,200
The State.....	24,363,000	22,757,000	24,727,000	25,159,000	275,000

July 1, 1990

County	BASELINE		ALTERNATE PROJECTIONS		Assumed Military
	Series D-100	Series E-0	Series D-150	Series C-150	
Los Angeles.....	7,346,800	6,571,100	7,396,900	7,609,000	24,200
Orange.....	2,465,300	2,194,900	2,560,900	2,625,100	11,100
San Diego.....	2,242,300	2,044,400	2,397,900	2,458,700	97,400
Ventura.....	704,400	601,600	730,500	749,700	6,000
Santa Barbara.....	361,900	326,500	367,800	376,600	5,500
Southern California....	13,120,700	11,738,500	13,454,000	13,819,100	144,200
The State.....	26,098,000	23,573,000	26,738,000	27,445,000	275,000

Table II-102 (Cont.)

July 1, 2000

County	BASELINE	ALTERNATE PROJECTIONS			Assumed Military
	Series D-100	Series E-0	Series D-150	Series C-150	
Los Angeles.....	7,850,400	6,530,800	7,935,800	8,356,200	24,200
Orange.....	2,810,600	2,377,700	2,945,600	3,071,500	11,100
San Diego.....	2,654,100	2,260,100	2,919,800	3,046,500	97,400
Ventura.....	870,900	676,000	946,400	985,200	6,000
Santa Barbara.....	413,600	345,800	425,100	442,400	5,500
Southern California...	14,599,600	12,190,400	15,172,700	15,901,800	144,200
The State.....	29,277,000	24,746,000	30,489,000	31,870,000	275,000

July 1, 2010

County	BASELINE	ALTERNATE PROJECTIONS			Assumed Military
	Series D-100	Series E-0	Series D-150	Series C-150	
Los Angeles.....	8,492,700	6,448,500	8,650,600	9,399,300	24,200
Orange.....	3,153,900	2,509,700	3,308,800	3,542,800	11,100
San Diego.....	3,130,900	2,474,200	3,501,200	3,751,700	97,400
Ventura.....	1,034,400	731,900	1,167,200	1,242,400	6,000
Santa Barbara.....	470,400	361,800	487,800	520,700	5,500
Southern California...	16,282,300	12,526,100	17,115,600	18,456,900	144,200
The State.....	32,787,000	25,683,000	34,626,000	37,178,000	275,000

Table II-102 (Cont.)

July 1, 2020

County	BASELINE	ALTERNATE PROJECTIONS			Assumed Military
	Series D-100	Series E-0	Series D-150	Series C-150	
Los Angeles.....	9,255,800	6,371,800	9,496,300	10,681,600	24,200
Orange.....	3,493,500	2,610,000	3,668,600	4,046,000	11,100
San Diego.....	3,655,600	2,689,900	4,143,000	4,565,400	97,400
Ventura.....	1,195,900	775,800	1,388,600	1,515,200	6,000
Santa Barbara.....	531,500	376,600	555,300	609,500	5,500
Southern California...	18,132,300	12,824,100	19,251,800	21,417,700	144,200
The State.....	36,605,000	26,535,000	39,124,000	43,268,000	275,000

¹ D-100 etc. Letter designates key to assumed future fertility levels (D,E,C), while numerical designates key to assumed future annual net migration rate.

Letter - assuming a future fertility level of: c = 2.8, D = 2.5, E = 2.1

Number - assuming a future net migration rate from 0 to 150,000 people

² Totals of the 5 coastal counties

Source: State of California Department of Finance, Population Research Unit.

LOS ANGELES COUNTY

Population Characteristics, April 1970

Racial or ethnic group	Total	Percent	Male	Female
Total.....	7,036,500	100.0	3,402,900	3,633,600
White.....	6,030,000	85.7	2,918,900	3,111,100
Black.....	762,900	10.8	362,500	400,400
Japanese.....	104,100	1.5	50,400	53,700
Chinese.....	40,800	.6	21,100	19,700
Filipino.....	33,500	.5	18,000	15,500
American Indian.....	24,500	.3	11,700	12,800
Other.....	40,700	.6	20,300	20,400
Spanish American (a).....	1,289,300	18.3	632,200	657,100

Source: U. S. Census of Population, 1970.

(a) In the racial distribution most Spanish Americans are counted as White; the rest are distributed among the other racial categories.

Estimated population, July 1974: 6,961,200

COMMUNITY CHARACTERISTICS

More than one-third of California's population is centered in Los Angeles County. With approximately seven million residents Los Angeles ranked as the leading county in the nation and is larger in population than 42 of the 50 states, according to the 1970 U. S. Census.

About 85 percent of the population is concentrated in the 77 cities in the county. As of January 1974 the city of Los Angeles, with a total of 2,745,300 residents, is the largest in the county. Long Beach is next with 344,500 followed by Torrance, 135,200; Glendale, 130,500; and Pasadena, 109,700. Thirteen cities have populations in excess of 75,000 at the present time.

As of the 1970 census nearly one-third of the population was made up of minority ethnic groups. Spanish-Americans, by far, constitute the largest minority group, and comprise 18.3 percent of the county's population. About 10.8 percent are Blacks, while 3.5 percent are in other nonwhite categories.

Located in the southern part of the state, bounded on the south and west by the Pacific Ocean, extending some 70 miles across and about 75 miles from the Los Angeles Harbor to its northernmost point, the county covers an area of 4,069 square miles. The topography varies from flat desert area in the north separated by a low mountain range from the heavily populated San Fernando and San Gabriel Valleys. To the west lie the ocean front and beach communities. Los Angeles County has a moderate climate and a relatively low humidity reading throughout the year.

The county is the commercial center of Southern California with executive and administrative offices for all types of industrial, business, and governmental activities located here. The area remains one of the leading aerospace centers of the nation. Motion picture production, tourism, medical health services and business services which includes research, engineering and computer services, are important facets of the local economy.

ORANGE COUNTY

Population Characteristics, April 1970

Racial or ethnic group	Total	Percent	Male	Female
Total.....	1,420,386	100.0	697,690	722,696
White.....	1,381,742	97.3	678,426	703,316
Black.....	10,179	0.7	5,306	4,873
Japanese.....	10,645	0.7	4,772	5,873
Chinese.....	2,832	0.2	1,447	1,385
Filipino.....	3,141	0.2	1,855	1,286
American Indian.....	3,920	0.3	1,926	1,994
Other races.....	7,927	0.6	3,958	3,969
Spanish American (a).....	160,168	11.3	80,064	80,104

Source: U. S. Census of Population, 1970.

(a) In the racial distribution most Spanish Americans (96.9%) are counted as White; the rest are distributed among the other racial categories.

Estimated Population, July 1974: 1,656,300

COMMUNITY CHARACTERISTICS

Orange County lies along 40 miles of Southern California coast between Los Angeles and San Diego Counties, and extends some 25 miles inland. The area covers more than a half million acres, three-fourths of which is privately owned. The eastern mountain region is largely uninhabited and the population is mostly contained within the 327 square miles of incorporated cities in the northeast corner of the county and stretching south along the coast.

Orange County, the second most populous county in California, practically doubled its population in the ten years between 1960 and 1970. This growth rate was the second highest recorded nationally for a major labor market area. Between 1970 and 1972 the largest population gains

took place in the cities of Huntington Beach, Anaheim, Fountain Valley, Santa Ana, and Irvine, in that order. Garden Grove and Buena Park registered small losses in population but in the past year both areas have shown small gains.

Ethnic minorities comprise less than 14 percent of the population in the county, considerably under the state-wide figure of 26 percent. The median family income of \$12,244 at the time of the census was the highest for any county in Southern California.

The county is served by an extensive network of freeways linking it to Los Angeles and surrounding counties. In addition to the Orange County Airport serving approximately one million passengers per year, there are two privately operated airports and the publicly-owned Fullerton Municipal Airport.

Lack of transportation other than private automobiles is a major problem. At the time of the census 85 percent of the workers in the county drove their own cars to work and another 8 percent were passengers in private automobiles. Three percent walked to work, 2 percent worked at home, and only 0.3 percent rode the bus. There is virtually no public transportation linking the residential areas with the major industrial centers.

SAN DIEGO COUNTY

Population Characteristics, April 1970

Racial or ethnic group	Total	Percent	Male	Female
Total.....	1,357,854	100.0	703,294	654,560
White.....	1,251,801	92.2	647,127	604,674
Black.....	62,028	4.6	33,241	28,787
Japanese.....	7,515	0.6	2,653	4,862
Chinese.....	3,259	0.2	1,700	1,559
Filipino.....	14,721	1.1	8,426	6,295
American Indian.....	5,880	0.4	3,243	2,637
Other races.....	12,650	0.9	6,904	5,746
Spanish American (a).....	174,209	12.8	88,964	85,245

Source: U. S. Census of Population, 1970.

(a) In the racial distribution most Spanish Americans are counted as White; the rest are distributed among the other racial categories.

Estimated population July, 1974: 1,509,900

COMMUNITY CHARACTERISTICS

San Diego County is the southwest corner of the United States and of the State of California. It covers 4261 square miles and is bounded on the west by the Pacific Ocean and on the south by Mexico. San Diego is joined on the north by Orange and Riverside Counties while the eastern extremity is defined by Imperial County. Altitude ranges from sea level along the 75-mile coastline to 6,533 feet at the top of Hot Springs Mountain.

In 1542 Juan Rodriquez Cabrillo sailed into the harbor of San Diego; the first mission in California was founded in San Diego in 1769; and by 1850 when California joined the union, San Diego County was one of the original 27 counties. The county is larger in land area than the combined areas of Rhode Island, Delaware, and the District

of Columbia, and had a larger population than 16 individual states at the time of the 1970 census.

During the latest census, 1,357,854 people were counted living within the county, for a 31.4 percent increase from the 1,033,011 residents in 1960. Estimates by the California Department of Finance place the county's population for July 1974 at 1,509,900 for an increase of 11 percent since April 1970. San Diego County's population is highly concentrated in a fairly narrow band stretching along the seacoast from Baja, California up to the Camp Pendleton Marine Base just above the city of Oceanside.

There are 13 incorporated cities within the county. The largest of these is the city of San Diego with just over half the county's population concentrated within its boundaries. One of the prominent features of the county's geography is San Diego Bay, a natural harbor and one of California's deep water ports. It serves as a port for the Navy's First Fleet as well as being a port-of-call for cargo vessels and passenger ships. Four major interstate freeways originate in San Diego and air transportation is provided by eight scheduled air lines.

The community is probably best characterized by its education and research facilities and as a tourist and convention center.

VENTURA COUNTY

Population Characteristics, April 1970

Racial or ethnic group	Total	Percent	Male	Female
Total.....	376,430	100.0	186,972	189,458
White.....	361,361	96.0	179,706	181,655
Black.....	6,354	1.7	3,114	3,240
Japanese.....	2,484	.7	1,056	1,428
Chinese.....	714	.2	360	354
Filipino.....	1,550	.4	824	726
American Indian.....	1,150	.3	558	592
Other races.....	2,817	.7	1,354	1,463
Spanish American (a).....	73,684	19.6	37,349	36,335

Source: U. S. Census of Population, 1970.

(a) In the racial distribution most Spanish Americans are counted as White; the rest are distributed among the other racial categories.

Estimated population, July 1974: 426,000

COMMUNITY CHARACTERISTICS

Ventura County, with an area of 1863 square miles, ranks 26th in size among California's 58 counties. The county is bordered on the north by Kern County, and on the southeast by the metropolitan area of Los Angeles. The Pacific Ocean provides the county's southwestern border stretching along 42 miles of coastline. Most of the northern half of the county is part of the Los Padres National Forest. The mountain ranges extend in an east-west direction creating fertile valleys and broad alluvial basins, primarily in the southern half of the county which includes the major cities of Oxnard and Ventura. The area's highest point is the 8,831 foot Mt. Pinos, located in the Los Padres National Forest.

The county boasts the Channel Islands Marina, the rehabilitated Ventura Marina, miles of clean beaches, and lakes. In addition, the offshore island of Anacapa is ripe with development opportunities. The Port of Hueneme, located just south of Oxnard, is the only deep-water general cargo port between Los Angeles and San Francisco.

Total population in Ventura County increased by nearly 90 percent between 1960 and 1970 for the second fastest growth rate among California counties during the decade. The area's rapid population expansion was due in part to the proximity of the county to the Los Angeles metropolitan area. More than 50 percent of the people who live in the eastern part of the county, notably in the Simi and Conejo Valleys, commute to jobs in Los Angeles County. Consequently, these areas showed the most momentous gains in population between 1960 and 1970.

Ventura County can be characterized as having a very young population. More than one-third of the area's residents are 15 years of age and under, compared to the national average of approximately 28 percent. In addition, the 5-9 year old population showed growth in the county during the 1960's while that of the nation declined.

The Ventura County Airport in Oxnard provides passenger and freight service. Local transportation is provided by the Greyhound Bus Lines and the Southern Pacific and Santa Fe Railroads. Several major truck lines also serve the area.

SANTA BARBARA COUNTY

Population Characteristics, April 1970

Racial or ethnic group	Total	Percent	Male	Female
Total.....	264,324	100.0	130,311	134,013
White.....	249,558	94.4	122,467	127,091
Black.....	6,426	2.4	3,444	2,982
Japanese.....	2,055	.8	927	1,128
Chinese.....	800	.3	442	358
Filipino.....	1,660	.6	1,025	635
American Indian.....	1,008	.4	529	479
Other races.....	2,817	1.1	1,477	1,340
Spanish American (a).....	45,856	17.3	22,805	23,051

Source: U. S. Census of Population, 1970.

(a) In the racial distribution most Spanish Americans are counted as White; the rest are distributed among the other racial categories.

Estimated population, July 1974: 279,800

COMMUNITY CHARACTERISTICS

Santa Barbara County is bordered on the east by Ventura County, on the north by San Luis Obispo and Kern counties, and on the south and west by 107 miles of coastline of the Pacific Ocean. The county is over twice the size of the state of Rhode Island and with a total area including the Channel Islands of 2737 square miles. Much of Santa Barbara County is mountainous and nearly 40 percent of the total land area is either farmed or cultivated. The Sierra Madre, Santa Ynez, San Rafael mountains rim numerous fertile areas including the Santa Maria, Cuyama, Lompoc, and Santa Ynez Valleys, and the southwest coastal plain. These areas, which include most of the developed land, also accommodate the majority of the population.

The climate is equable throughout the year. Dry, rainless summers are followed by a season in which the average rainfall varies from 14 inches in the valleys to 18 inches on the coast. The average daily temperature is a maximum of 70.5 and a minimum of 49.2.

The population of Santa Barbara County increased by 52.5 percent between 1960 and 1970, far surpassing the growth rates of California and the United States. The rapid population expansion in the county was mainly due to the development of the Vandenberg Air Force Base during the late '50s and early '60's, a continuous inflow of retired persons, a substantial buildup of industrial and commercial activities in the Goleta Valley area, and steady growth at the University of California at Isla Vista.

The growth rate of the older members of the population has been very pronounced and is expected to hold at a substantial pace. Approximately 9.1 percent of the total county population was 65 years old or more, far above the statewide elderly-to-total ratio. The proportion of Spanish-surname individuals to the county total exceeded the comparable statewide ratio (15.5 percent), but the proportion of Blacks was much smaller than in the state.

Santa Barbara Municipal Airport and Santa Maria Public Airport provide passenger and freight jet service.

2. Employment

Even with the State's economic problems of 1970 and 1971, California's economy has done a good job of providing employment opportunities for its residents. From 1970 to 1973, 534,000 new jobs were created, almost 50,000 more than the increase in the civilian labor force during the 3 year period (Table II-103).

During the 1970-1971 recession, fluctuations in the economy impacted heavily on the labor force. Business conditions slowed during the recession, the labor force which had shown substantial increases during the sixties advanced slowly and virtually stabilized between 1970 and 1971. Unemployment was up sharply during this period and the unemployment rate averaged 7 percent during 1971. Had the labor force not stabilized during the recession, unemployment would have been considerably more severe.

Manufacturing, the largest employment category, was most affected, suffering the greatest loss in numbers of jobs during the downturn, but enjoying the greatest rebound in the recovery and expansion that followed. Historically, demand for manufactured goods follows (the rise and fall of) the overall business cycle. This recession which became evident in early 1970 was felt not only in California but nationally. However, the economy of the local region (Southern California) was further affected by cutbacks in the aerospace industry. As recently as 1968 employment in aerospace accounted for 12 percent of total employment. The turnaround occurred in late 1971. The economic expansion since then has been stimulated

TABLE II-103

Total Civilian Employment For
Southern California Coastal Counties
1970 Thru 1973, Forecast 1974
(Annual Averages)

County	Annual Averages (000) Estimated Forecast					Annual Change					
						Number (000)			Percent		
	1970	1971	1972	1973	1974	1972	1973	1974	1972	1973	1974
Los Angeles	3179	3117	3225	3321	3378	108	96	57	3.5	3.0	1.7
Orange	476	485	520	551	574	34	31	23	7.2	6.0	4.2
San Diego	444	457	479	493	502	22	14	9	4.8	2.9	1.8
Ventura	116	119	125	130	134	6	5	4	5.0	4.0	3.1
Santa Barbara	99	100	103	106	108	3	3	2	3.0	2.9	1.9
Southern California	4314	4278	4452	4601	4696	174	149	95	4.1	3.4	2.1
State Total	8036	8007	8314	8570	8725	307	256	155	3.8	3.1	1.8

Source: United California Bank

primarily by consumption of durable goods.

Trade industries provide the second highest number of jobs among Southern California industries. By early 1974 over 900,000 workers were employed in wholesale and retail trade, representing better than one out of five jobs. Traditionally, trade has been one of Southern California's most rapidly growing employment sectors and evidences less sensitivity to business fluctuations than most other industries. In 1973 there was an advance in consumer expenditures which impacted directly on trade employment. The present level of employment in the trade industries is sharply above the corresponding 1972 level.

The service industry, which ranks third in major employment sectors in Southern California, has reflected trends very similar to those in the trade category. The service industry which provides jobs to more than 750,000 people in the five coastal counties has also had recent gains in number of employees.

Government employment provides the fourth highest number of jobs in Southern California coastal countries. This sector evidenced strong growth in the sixties through the present time. This increase is almost entirely due to increases in state and local government, as federal employment has remained level since the middle 1960's.

The finance, insurance, and real estate industry complex was the only major sector in which employment growth was not adversely affected during the 1970 business slowdown. Demand for the services offered by this industry was strong enough to sustain employment

growth, which in recent years has averaged in excess of 3.6 percent annually.

Employment in transportation, communication and utilities reflected steady increases in the late 1960's which was followed by a cutback in 1970 and 1971 during the recession. Since that time steady increases have been made in this sector.

Los Angeles County, which accounts for more than 70 percent of the five Southern California coastal counties' employment (Table II-104, has historically registered the greatest numerical change in employment. However, the high degree of development leaves relatively little room for growth, and employment expansion consequently has been less rapid than in other large Southern California metropolitan areas. Despite recent diversification the vast aerospace complex is still centered in Los Angeles County, although certain industry shifts are currently underway. Therefore, cutback in NASA and Department of Defense contracts are felt to a greater extent in this area than in other Southern California employment centers.

Orange and San Diego Counties account respectively for approximately 12 and 11 percent of the five Southern California coastal counties' employment, and both have been registering rapid employment gains. Each of the two areas has ample room for further development and is expected to continue to register a considerably faster growth rate than the rest of the southern region.

Ventura and Santa Barbara Counties together account for less than 5 percent of the South Coast total work force. Although small in

TABLE II-104

Southern California Coastal Counties
Labor Market Trends
September 1972
(Thousands)

	Los Angeles	Orange	San Diego	Ventura	Santa Barbara	Total
Total Civilian Labor Force	3359.5	531.9	495.9	132.3	107.3	4626.9
Unemployment	171.5	26.1	26.1	6.6	5.3	235.6
Unemployment Rate (Seas. Adj.)	5.4	5.3	5.5	5.9	5.3	
Total Civilian Employment	3188.0	505.8	469.8	125.7	102.0	4391.3
Non-Agriculture Wage/Salary	2870.2	445.2+	411.6	100.1	83.4	3910.5
Manufacturing	789.6	121.4	57.9	14.1	9.6	992.8
Durable Goods	536.8	91.7	44.9	8.1	6.9	688.4
Non-Durable Goods	252.8	29.7	13.0	6.0	2.9	304.4
Non-Manufacturing	2080.6	323.8	353.7	86.0	73.6	2917.7
Mining	10.6	2.0	.5	1.7	.9	15.7
Construction	94.9	26.5	24.1	4.9	3.7	154.1
Transportation/Utilities	174.1	15.2	22.2	4.6	3.5	219.6
Trade	645.6	107.5	95.2	24.1	19.6	892.0
Finance/Ins./Real Estate	179.3	24.5	21.1	3.7	3.2	231.8
Services	544.5	77.7	84.0	16.2	21.2	743.6
Government ^a	431.6	70.4	106.6	30.8	21.5	660.9
Other Non-Agriculture Employment ^b	307.9	52.5	47.2	11.9	12.5	432.0
Agriculture Employment	9.9	8.1	11.0	13.7	6.1	48.8

^aIncludes civilian employees of Federal, State and Local governments.

^bIncludes domestics, self-employed and unpaid family workers.

Source: State of California, Employment Development Department

labor force, Ventura County continues to be one of the fastest growing regions in California. Of significance is that this area's employment growth is broadly based, as opposed to one industry inspired gains. Santa Barbara County has achieved some success in striving for controlled growth, but still is experiencing some economic expansion. Much of the recent growth has been in the trade and service sectors. An employment study, by county, describing labor market trends and employment by industry follows in table II-105.

Table II-105

EMPLOYMENT BY INDUSTRY
LOS ANGELES COUNTY
(Thousands)

Industry	July 1971	July 1972	July 1973
Total civilian employment	3,109.9	3,222.3	3,316.4
Nonagricultural wage and salary	2,793.1	2,905.0	2,998.5
Mineral extraction	10.7	11.1	11.2
Contract construction	99.4	102.1	104.9
Manufacturing	747.3	781.3	820.0
Nondurable goods	244.6	250.8	259.7
Food and kindred products	49.8	50.7	50.9
Apparel	54.8	59.0	61.7
Printing and publishing	40.0	40.4	41.1
Chemicals and allied products	28.3	27.8	29.9
Rubber and misc. plastics prdts	26.7	28.5	31.1
Other nondurable goods	45.0	44.4	45.0
Durable goods	502.7	530.5	560.3
Ordnance and accessories	19.2	14.4	15.5
Furniture and fixtures	26.3	29.5	31.7
Stone, clay and glass prdts	22.1	24.3	25.2
Primary metal industries	25.5	25.7	28.2
Fabricated metal products	63.5	68.2	70.9
Machinery, except electrical	69.7	73.1	78.2
Electrical machinery	98.5	104.7	115.5
Motor vehicles	21.5	20.5	23.2
Aircraft and parts	99.0	106.4	106.7
Instruments	20.0	21.6	23.0
Other durable goods	37.4	42.0	42.2
Transp., comm. and utilities	169.9	172.1	173.5
Trade	634.1	661.1	683.1
Wholesale	193.4	199.8	206.3
Retail	440.7	461.3	476.8
Finance, insur, and real estate	173.1	178.2	185.8
Services and miscellaneous	547.1	576.1	587.7
Government (a)	411.5	423.0	432.3
Other nonagricultural employment (b)	306.7	307.3	308.2
Agriculture	10.1	10.0	9.7

(a) Includes all civilian employees of Federal, State, and local governments, regardless of the activity in which employees are engaged.

(b) Includes employers, own-account workers, unpaid family workers, and domestic servants.

Source: State of California, Employment Development Department

Labor Market Trends

Los Angeles County is the second largest labor market in the country, surpassed only by the New York metropolitan area. The local economy is well diversified and closely resembles the national distribution of employment, both industrially and occupationally.

Manufacturing is the principal employer in the county. Approximately 27 percent or more than 1 out of 4 people employed in wage in salary jobs were in this goods producing sector of the economy. Aerospace manufacturing is a major component of this group and accounts for over 30 percent of the total jobs in manufacturing.

The next largest employer is trade which includes wholesaling and retailing activity. This sector employs approximately 23 percent of the wage and salary employees.

Ranking third in Los Angeles County (20 percent) is the diversified services industry which includes hospital and medical services, motion picture production and amusement and recreation centers. Another 14 percent are employed by governmental agencies of which more than 2 out of 5 are in public education providing the educational needs of the community.

Ranking fifth as an employment sector is the finance, insurance and real estate business which employs approximately 6 percent of the total wage and salary employees.

Seasonally, total employment reaches its peak in December and its low in January or February. The year-end high coincides with the Christmas season in trade and the low typically follows the post-

holiday retrenchment in retail trade and winter slack in construction. The service industry and the transportation-utilities group move up sharply in the summer as trucking firms and tourist-oriented hotels, and amusement recreation centers put on more workers, but government payrolls fall sharply in the summer as schools go on vacation schedules. Employment in nondurable goods manufacturing is influenced by strong seasonal patterns in apparel and food processing, and among the durable goods industries toy manufacturing, furniture, auto assembling, food container production, and building material suppliers are highly seasonal activities.

Manufacturing employment continued the uptrend that began in the closing months of 1971 and posted a better than average 6.1 percent advance during 1973 reflecting increased consumer demand for goods and business demand for new machinery and additions to inventory. The number of factory workers in 1973 was above the 1971 low, but was still short of the pre-recession 1969 average. If the fuel shortages continued, employment growth was expected to come to a virtual standstill in some industries in 1974. The transportation equipment sector had been hard hit by production cutbacks.

Excluding the aerospace complex of industries - ordnance, electrical machinery, aircraft and parts, and instruments - the other durable goods industries posted a strong 8.5 percent gain in 1973, coming on top of a 6.4 percent advance in 1972. The industries mainly responsible for the two-year improvement were the metals group, machinery categories, furniture and fixtures, lumber and wood, and

stone, clay and glass. The expansion in aerospace components employment, however, was substantially slower with their combined employment rising an average 3.9 percent in 1973. The current average was well below the 1967 peak. The durable goods industries as a whole averaged 6.4 percent above 1972.

In spite of spotting performances in food and kindred products and paper and allied products industries, employment in the nondurable goods industries registered a 5.4 percent advance in 1973, raising the industry group posted gains over the year, while employment in textiles, apparel, rubber and miscellaneous plastic products, and leather goods were at record levels in 1973. The outlook is for employment to continue to move up in 1974, but at a slower pace than in 1973 as soft spots were expected to develop because of the recent energy crunch.

Petroleum refining and related industries posted its first increase in employment in five years, rising from an average of 13,400 in 1972 to 13,700 in 1973. Employment in petroleum refining increased from 11,100 to 11,400 over the year as activity accelerated in the production of fuel. The job situation will remain good for workers in this industry as the local refineries are expected to be operating at a high level in 1974.

During the first half of 1973, year-over-year job growth held to an average gain of 4.6 percent. In the last six months of the year, the growth rate advanced to a lofty 6.2 percent in early fall, but by the end of the year it was evident the upward momentum was slowing as

the energy crisis began to curtail expansionary trends and cause layoffs in a variety of industries. For 1973 as a whole, the growth rate averaged 5.1 percent, but this was still the best annual growth rate since 1966.

At the beginning of 1974 a high degree of uncertainty was injected into the employment outlook because of the energy crisis. The shortage of petroleum products caused curtailments in production of transportation equipment, rationing of some other sources of energy, raw materials shortages, while tourism and related activities and commercial and business centers in outlying areas had been affected by the declining tavel. Despite these problems, employment growth is expected to continue in 1974, mainly in the service-producing sector of the economy, but at a substantially slower rate than in the year just ended.

The continuing high level of consumer spending in 1973 was reflected in a steady expansion in employment among the area's wholesalers and retailers. Trade employment in 1973 established a new high of 689,800, an increase of 5.0 percent over the 1972 level. Wholesale trade employment jumped by 7.2 percent to a record 211,200, while a moderate 4.0 percent rise was posted in retail trade, bringing the total to 478,600, a highest ever. Nearly one-half of the new jobs were created in eating and drinking places, but employment was also expanding strongly in miscellaneous retail stores and furniture outlets in 1973. Food stores averaged fewer employees in 1973 than in the previous year as trade disputes depressed the total. Automobile service stations were one of the first to feel the pinch

of the nation's dwindling fuel supplies. By the end of the third quarter of the year, most stations were closed on Sundays and working shorter hours. A few station closures were also noted. Sales of large cars began to fall sharply as the fuel shortage worsened, and in turn resulted in layoffs of salesmen among new car and used car dealers. A slowdown in employment growth was looked for in 1974, as an energy crisis-related travel decline would adversely affect shopping centers in outlying areas and automobile related services.

The improved economic conditions in 1973 brought a substantial upturn in employment in the service industries. All segments of this diverse industry responded by hiring additional workers and most reported record employment totals in 1973. Amusement and recreation centers enlarged their staffs substantially last year, while both legal and miscellaneous professional services reported nearly an 11 percent expansion in work force in 1973. Employment in miscellaneous business services rose sharply to meet the increasing demand of commercial and industrial customers, while employment in personal service activities made a slight comeback last year. Medical and other health services continued to expand in both health care and employment and private educational services also registered a steady rise in personnel. Motion picture employment gained for the second consecutive year following slack years in 1970 and 1971. On the whole, service industries added an estimated 40,000 new workers in 1973. The widening impact of the energy crisis was expected to affect the expansion in the service industry in 1974. Substantial

slackening is looked for in amusement and recreation activities, as well as in hotels, motels and other lodging places.

The long term expansion in government employment slowed sharply in 1973, rising by less than one percent (0.6) to 438,900 from the 1972 level of 436,200. Federal employees declined over the year as work force reductions occurred in both defense and nondefense activities. Sagging school enrollment in many districts largely offset gains in expanding areas, holding the increase in education personnel to less than one half of one percent at a monthly average of 184,500 in 1973. Employment growth also slowed in city and county governments, and employment in State agencies held close to year ago levels.

Employment growth in finance, insurance and real estate averaged 4.6 percent during 1973. Job growth was particularly marked in real estate reflecting a high level of activity in the construction industry which itself advanced almost 10 percent.

The employment expansion in 1973 was broadly based and represented an upturn in demand for virtually all types of workers. The available supply of job seekers reduced by 16 percent during the year. Although this was the smallest number of available workers in the past four years, there were few signs of a tightening in the labor demand and supply relationship in any occupational classification. But there were some categories in which recruitment difficulties persisted, particularly in occupations in which there is high turnover. The problem frequently involved low or unrealistic wage offers,

unattractive working conditions, lack of advancement opportunities, traveling distances and a negative social image. On the other hand, some openings were hard-to-fill because of unrealistic hiring specifications related to training and experience requirements.

Worker recruitment in trade and services was active in 1973, although trade disputes in the latter part of the year adversely affected the transportation communications and retail trade divisions. Manufacturing employment, while higher than in 1972, is still well below its level of four years ago. This has had a significant effect upon the supply-demand relationship of many occupational categories. A surplus of workers now exists where previously the demand has exceeded the supply of experienced workers. These occupations include the engineering, drafting and other technical categories, and all but the most highly skilled production jobs. Many clerical, service and laborer classifications continue to show large numbers of applicants for the openings that exist.

Complementing the employment picture, the number of jobless workers in 1973 dropped to 203,000 per month, compared with an average of 242,000 per month in 1972. As a percent of the civilian labor force, joblessness declined from 7.8 percent in 1972 to 6.5 percent in 1973, the lowest level experienced since 1969. Since then the adjusted unemployment rate rose to 7.0 percent in August 1974 and a month later was at 7.3 percent, the highest to date for the year. Layoffs in chemicals, furniture and machine factories were contributing factors.

Table II-106

EMPLOYMENT BY INDUSTRY
ORANGE COUNTY
(Thousands)

Industry	July 1971	July 1972	July 1973
Total civilian employment	490.5	523.7	557.0
Nonagricultural wage and salary workers	432.0	463.1	495.5
Manufacturing	118.2	126.5	134.9
Nondurable goods	27.9	29.2	31.3
Food products	6.9	7.3	7.5
Textile and apparel	2.5	2.8	3.2
Paper and printing	8.2	8.6	8.9
Chemicals and petroleum refining	4.2	4.2	4.5
Rubber and plastics	6.1	6.3	7.2
Durable goods	90.3	97.3	103.6
Lumber and furniture	2.7	3.6	4.3
Stone, clay, and glass	2.8	2.8	2.8
Primary and fabricated metals	9.7	11.1	12.2
Nonelectrical machinery	11.1	11.4	13.4
Aerospace	54.0	58.3	59.8
Electrical machinery	33.0	33.5	34.2
Ordnance and aircraft	14.3	17.5	17.2
Instruments	6.7	7.3	8.4
Transportation equipment (exc.aircraft)	4.9	5.6	6.2
Other manufacturing	5.1	4.5	4.9
Nonmanufacturing	313.8	336.6	360.6
Mining	1.9	2.0	2.0
Construction	25.6	28.1	29.3
Trans., communications, and utilities	15.5	16.2	16.9
Trade	103.9	110.0	119.4
Wholesale	15.0	16.2	17.9
Retail	88.9	93.8	101.5
Finance, insurance, and real estate	22.7	24.8	27.1
Services	77.9	84.6	90.4
Government (a)	66.3	70.9	75.5
Federal	8.2	8.3	8.8
State and local	58.1	62.6	66.7
All other nonagricultural employment (b)	51.5	52.4	52.5
Agriculture	7.0	8.2	9.0

(a) Includes all civilian employees of Federal, State and local governments, regardless of the activity in which employees are engaged.

(b) Includes employers, own-account workers, unpaid family workers, and domestic servants.

Note: In the individual city surveys, June employment figures for public schools were used rather than July. For comparison purposes the county-wide figures shown above would require an upward adjustment.

Source: State of California, Employment Development Department

Labor Market Trends

Employment at Orange County establishments passed the half-million mark in 1972. From June 1973 to June 1974 total employment was up 6.5 percent. During this same period manufacturing accounted for 23 percent of all jobs in the county down from 31 percent in 1967 at the height of the aerospace boom. The current industry mix is well diversified with trade representing 20 percent of the total, service 16 percent, government 13 percent, construction 5 percent, and finance, insurance and real estate which ranks as the fifth largest employer with 4 percent of total employment.

The manufacturing sector the largest employer in the county achieved a 6.9 percent annual growth rate. This is slightly higher than that reflected by total employment growth. The aerospace industry which is the largest group under manufacturing reflected a weak growth of 2.3 percent. This can be largely attributed to cutbacks in aircraft and ordnance production. The manufacturing sectors showing the largest growth were nonelectrical machinery 29 percent, aerospace instruments 21 percent and lumber/furniture reflecting a 19 percent growth compared to the same period a year earlier (June 73-74).

The trade and service industries which rank second and third in total number of employees grew at approximately the same levels (8 percent). Government employment was up 5.2 percent with state and local government accounting for the major share. Only 1 out of 10 government employees are on the federal payroll. Contract construction was up almost 6 percent. This is significant insofar as construction

is off sharply statewide. The reason for this relative strength is the continuing demand for housing throughout the county, a situation that results from the large immigration.

Unemployment rose sharply from 37,200 in June 1973 to 45,000 in June 1974 to reflect a seasonally adjusted rate of 5.8 percent. This compares with 7.5 percent for the state as a whole and 5.2 percent for county over the same period. The unemployment rate by August 1974 was up to 6.0 percent and by September had reached 6.5 percent as a result of a strike and general slowdown in the economy.

The resident working force in Orange County is highly mobile. Thirty percent worked outside of the county in 1970 - up from 27 percent ten years earlier. The higher out-commuting resulted partly from the large aerospace layoffs and the lack of jobs in the local area and partly from the residential advantages in Orange County, such as lower land and housing costs. Since 1970 the availability of jobs within the county has increased rapidly and the extent of out-commuting may be somewhat less. Except for the lack of public transportation, the labor supply is readily available to employers anywhere in the county and in much of the concentrated industrialized areas of Los Angeles County.

Seasonality in the various industries within Orange County is counter-balanced so that generally there are no large month-to-month seasonal fluctuations in the working force as a whole. The greatest number of farm workers are needed in May and June, but the demand is sustained through the summer months. Recreation and tourism

give a big boost to the service industry during the summer. Construction activity is above average from April through September, and is subject to heavy reductions during rainy weather in the winter. Food processing reaches a seasonal peak in August and September, while wholesale citrus packing is most active in the second quarter of the year. Retail stores do their largest volume of business in November, December, and January, and government payrolls are sharply reduced during the summer when public school staffs are idled.

Recreation and tourism are prominent components of the county economy--Disneyland, Knott's Berry Farm, the Angels' Stadium, Lion Country Safari, Movieland Wax Museum, and beach resorts draw millions of visitors into the area each year. Hotels, restaurants, retail stores, and services all benefit from the tourist business as well as rapidly expanding resident population

Labor Market Trends

San Diego started as an agricultural community and then because of the climate and beaches became popular as a resort area. The onset of World War II along with a favorable climate resulted in the location and rapid growth of an aircraft industry in San Diego. During the 1950's aircraft employment zoomed reaching a peak in mid-1957 when nearly 60,000 workers were employed in the industry. Missile production cushioned losses in aircraft employment in 1958 through 1960 but during the early 1960's both groups were hard hit by cutbacks and phaseout of contracts; by 1965 almost 34,000 employees had been released.

Table II-107

EMPLOYMENT BY INDUSTRY
SAN DIEGO COUNTY
(Thousands)

Industry	July 1971	July 1972	July 1973
Total civilian employment	465.1	486.1	491.5
Nonagricultural wage & salary workers . .	406.1	426.4	430.6
Mining	.6	.5	.5
Contract construction	24.8	27.2	25.0
Manufacturing	63.8	61.6	63.6
Food products	3.8	3.9	3.9
Apparel	2.5	2.8	3.5
Printing and publishing	4.5	4.6	4.8
Nonelectrical machinery	5.3	5.4	6.1
Electrical machinery	9.1	9.8	9.8
Aircraft and ordnance	26.0	22.2	20.8
Shipbuilding	4.9	3.9	5.1
Other manufacturing	7.7	9.0	9.6
Trans., communication, & utilities . . .	21.8	22.3	23.2
Wholesale & retail trade	88.7	93.2	96.7
Finance, insurance & real estate	19.9	22.1	23.7
Service	82.6	88.7	89.1
Government (a)	103.9	110.8	108.8
Other nonagricultural employment (b) . . .	47.7	49.0	50.2
Agricultural	11.3	10.7	10.7

(a) Includes all civilian employees of Federal, State, and local governments, regardless of the activity in which the employees are engaged.

(b) Includes employers, own-account workers, unpaid family workers, and domestic servants.

Source: State of California, Employment Development Department

During the Vietnam buildup the local economy expanded and diversified; but the rate of gain in aircraft employment more than matched the overall growth rate of the economy during the period. Budget cutbacks in defense and space programs in 1968 and 1969 reduced aircraft-ordnance employment to about 22,000 in 1972.

Apparel, electronics, and shipbuilding were the major expanding components in the factory sector reporting sufficient increases to partially offset the loss of jobs caused by the reductions in the aircraft-ordnance group.

Tourism has been a major factor in the growth and diversification of the local economy. Numerous large new hotels and new convention facilities have given the area the capability of handling the largest conventions. A variety of recreational and leisure time activities help attract visitors to San Diego.

San Diego's recent growth has been based at least in part upon the availability of highly skilled personnel who are attracted here by the work opportunities in sophisticated new industries and educational opportunities such as in the nine colleges and universities which have an enrollment of over 100,000 full-time students. The growth of the schools has made education one of the county's largest employing industries.

After several years of swift growth in San Diego County, nonagricultural wage and salary employment slowed in 1970 and 1971 along with the national economy. By the end of 1971 employment gains began to pick up in pace and the 1972 annual average posted a 6.0

percent rise over the previous year. During 1972 there were more jobs added to the local economy in the one year than the total for the previous two years.

Nonagricultural wage and salary employment moved upward briskly during 1973 as the number of jobs climbed to an all-time high. These estimates for 1973 indicate an employment growth of 6.7 percent over the previous year's average and a gain of 106,700 new jobs in the county since 1968.

Although manufacturing employment showed only the third largest increase among the major industry divisions in annual average employment during 1973, the advance was perhaps the most optimistic sign of the year. The number of factory jobs averaged 69,300 for the 12-month period, up 7.8 percent from the previous year's figure of 64,300. Factory jobs now comprise approximately 15 percent of the total nonagricultural wage and salary employment, and while still an important part of the local economy have been accounting for a dwindling share of the market. Manufacturing employment reached its peak in 1959 when 72,700 workers were on factory payrolls. Two other times, in 1957 and again in 1961, employment rose above the 70,000 level. In the earlier days it was the aircraft-ordnance industry, which once hired better than three out of every four factory workers, that boosted manufacturing employment. During recent years the aircraft-ordnance sector has shrunk to about one-third of its former size while other sectors have taken up some of the slack.

During 1973 aircraft-ordnance employment was at the lowest level since 1950. The number of jobs in the component were on a steadily downward trend since late in 1968 through 1972. This once all-important sector of San Diego's economy is now smaller than such sectors as medical services and eating and drinking establishments and is less than half the size of public education.

An increase of almost 8 percent was made in trade employment in 1973 which compares with a 5 percent increase in the previous year. As a result of strikes in October by the workers in the retail food industry and drivers in the wholesale liquor trade employment reached its peak in September. Normally the fourth quarter is the strongest period for this division.

An increase of 7.2 percent in employment was shown by the finance, insurance and real estate group during 1973. Although the increase was a fairly large one, it fell far short of the rise in 1971 or 1972. The rapid gains over the past few years have been tied in part to the record years in real estate and the homebuilding boom of the 1970's. The number of banks and bank branches have also expanded at a rate faster than the growth in population.

Jobs in the service industries were up 8.4 percent compared to the 1972 average. The fastest growing component of the division was the medical services group which accounted for just over 2,000 of the new jobs in the service industry. The opening of several new facilities--some expansion of existing facilities and others completely new projects--provided most of the increase. Also up 1,000 was the hotel-

motel group as 1973 proved to be one of the best when measured by convention and tourist business. Along with the gains in lodging establishments, amusement and recreational services, and miscellaneous services, which include some tourist-supported facilities, also gained in employment during 1973. Every component of the service industry advanced over the previous year's figure. The apparent growth in miscellaneous business services was held down in 1973 to an increase of 300 after a setback of 200 the previous year.

Government employment was up 4.1 percent in San Diego County in 1974. This increase can be mainly attributed to an increase in public education. Government is not only the largest employment division in San Diego but the proportion of public workers to total employment is greater than that for the state or the nation. There are many reasons for this disproportionate number of government employees. The large military bases in the county, comprising approximately one-third of the active military personnel in California, employ numerous civilians. The proximity of the international border creates many extra federal jobs while the prime contributors to a higher than normal ratio of state and local public employees are the two State Universities located in the county.

The adjusted unemployment rate in San Diego County was at 10.1 percent in September 1974 which is the highest monthly unemployment since March 1971. This basically can be attributed to a general slowdown in the economy during the year and construction strikes in July and September.

Table II-108

EMPLOYMENT BY INDUSTRY
VENTURA COUNTY
(Thousands)

Industry	July 1971	July 1972	July 1973
Total civilian employment	119.3	125.6	129.7
Nonagricultural wage & salary workers . .	94.7	101.0	103.7
Mining	1.7	1.6	1.6
Contract construction	5.0	5.2	5.4
Manufacturing	12.7	13.7	14.0
Food products	1.3	1.4	1.4
Paper, printing, & publishing	1.7	1.8	1.8
Petroleum & chemicals	.4	.3	.3
Primary & fabricated metals	1.0	1.0	1.0
Nonelectrical & electrical machinery.	2.6	2.8	2.9
Transportation equipment	2.9	3.0	3.1
Other manufacturing	2.8	3.4	3.5
Trans., communication & utilities . . .	4.3	4.5	4.6
Wholesale & retail trade	23.2	24.4	25.5
Finance, insurance & real estate . . .	3.4	3.6	3.6
Service	15.2	17.2	18.2
Government (a)	29.2	30.8	30.8
Other nonagricultural employment (b) . .	11.7	11.9	11.9
Agriculture	12.9	12.7	14.1

- (a) Includes all civilian employees of Federal, State, and local governments, regardless of the activity in which the employees are engaged.
(b) Includes employers, own-account workers, unpaid family workers, and domestic servants.

Source: State of California, Employment Development Department

Labor Market Trends

Ventura County is in transition from almost total dependency upon agriculture to a metropolitan complex of light manufacturing, retail shopping centers and residential communities. Between 1967 and 1972, agricultural employment in the county remained about even; however, the farm-to-total worker ratio has dropped from 20 percent in 1957 to 11 percent currently. The major gains in employment during this

period have occurred in the government, trade, services, and manufacturing industries, in that order.

Total civilian employment in the county exhibited strong growth patterns in 1972 and 1973 following the 1970-71 economic slowdown. During 1972, employment rose at an annual 5.0 percent rate or nearly two times the increase shown during the previous year. A further expansion occurred in 1973 as the year was characterized by record levels of employment.

Approximately 30 percent of the county's wage and salary jobs during the first six months of 1974 were in government and another 23.5 percent were employed in trade. Services followed with 18.3 percent while manufacturing was closely behind accounting for 14.3 percent of the total

The number of wage and salary jobs in 1971 rose only fractionally as the recession limited growth in most industries. Manufacturing employment was hit hardest during the year with layoffs in aerospace firms primarily responsible. The economy recovered in 1972 as some aerospace workers were recalled and large gains were posted in service-producing industries. The recovery gained momentum in 1973 with wage and salary employment advancing by 5.2 percent as all major industries showed year-to-year employment increases except for mining and construction. The largest absolute gains occurred in services, manufacturing, retail trade, and government, in that order, and every major industry except mining was at an all-time high.

During the first half of 1974, employment expanded at a 5.6 percent annual rate. Manufacturing and services employment slowed down somewhat during the period but the net gain in the six-month span was bolstered by exceptional gains in public education. Retail trade employment continued to expand while construction activity was at its highest level in three years during June.

The government sector is the largest single employing division in the county, accounting for approximately 30 percent of all wage and salary workers. Public education is the leading employer in government while the number of State workers remains high due mainly to jobs at Camarillo State Hospital. Most of the federal civilian employees work at the Pacific Missile Range in Point Mugu and the Naval Construction Battallion Center in Port Hueneme.

Between 1970 and 1973, the main impetus in employment occurred at the state and local levels, notably education, while federal defense-related establishments lost workers primarily due to a hiring freeze imposed at Point Mugu during most of this time.

Government employment moved ahead to a first half average of 33,600 in 1974, an increase of almost 6 percent from the year before and was primarily due to staff increases in the county's two junior colleges.

Retail trade, like services, grew over the years primarily to meet the rising demands of an expanding population. Between 1970 and 1973, the industry increased its payrolls by 2,600 jobs, a gain of almost 15 percent during the period. Yearly, the industry employment rose by 5.3 percent in 1972, and 5.1 percent in 1973, following

a recession-dampened gain of 3.3 percent in 1971.

The fastest growing industry in terms of employment between 1970 and 1973 was the services industry because of the expanding demand for all types of services of an increasing population. On a year-to-year basis, services employment grew 3.3 percent in 1971; 13.0 percent in 1972; and 11.5 percent in 1973. The overall gain in 1973 was spread generally among most component groups with the largest increases occurring in medical and other health facilities and in research and development firms.

Manufacturing also was affected by the 1971 recession with the number of factory workers in the county declining by nearly 4 percent during the year. However, an upturn in capital spending and a rebuilding of inventories supported a renewed employment growth of 7.6 percent in 1972 and 7.7 percent in 1973. The growth rate, however, has slowed in the first six months of 1974 as a result of a trade dispute and a layoff in durable goods manufacturing and material shortages. Manufacturing employment averaged 15,700 in this period, and increase of 5.4 percent from the first half in 1973.

In the manufacturing durable goods sector nearly two out of every three workers are employed by aerospace firms and as a result, trends in durable goods employment are dominated mainly by the pattern set by the aerospace industry. The aerospace employment buildup began in the early 1960's when several new firms engaged in aircraft production moved to the area mainly from older plants in Los Angeles County and to be near the Pacific Missile Range in Point Mugu. Aerospace employment

expanded through the mid-sixties and reached a peak in 1968 when the industry averaged 8,500 workers. During the next three years, layoffs occurred as aircraft production dwindled and by 1971 only 5,400 workers were employed in the industry. A slight recovery trend took place over the next two years and in 1973 the industry averaged 6,100 workers. Aerospace employment expanded moderately in the first half of 1974 from 6,300 in January 6,600 in June with all gains occurring in the aircraft and parts and electrical machinery groups.

The increases posted by aerospace during the opening half of 1974 were moderated by losses which occurred in the other durable goods category. The most significant declines took place in June when the cancellation of a contract involving fiberglass barges forced the first stage of a large layoff in transportation equipment and a trade dispute idled many workers at a firm engaged in manufacturing non-electrical machinery.

Employment in the nondurable goods producing sector dropped fractionally in 1973 as gains in food processing plants and apparel manufacturers were negated by employment losses caused by a large paper company closing. Nondurables employment has risen so far in 1974 paced by seasonal and expansion hiring in food processing firms. Overall growth, however, was limited by a moderate layoff in the plastics industry in January as material shortages curtailed production of some items.

Manufacturing employment is expected to show a further slackening in the current expansion trend during the remaining months of 1974. The heaviest impact is expected in transportation equipment production as

the final stage of a previously announced layoff occur. Aerospace employment is expected to gain fractionally during the final months of the year due mainly to further expansion in the electrical equipment and supplies group.

Over the three year period of 1971 through 1973 construction employment remained relatively unchanged. During the first six months of 1974 employment in this field was up 8.7 percent compared to the same period of 1973.

All of the expansion took place among special trade contractors which includes contractors who undertake specialized activities such as plumbing, painting, plastering, carpentering, etc.

The seasonally adjusted unemployment rate was only 5.6 percent at the beginning of 1970 but ten months later it had risen to a peak in the seventies of 8.8 percent. The jobless rate remained high during the height of the recession in 1971 and ended the year with a twelve month average of 7.8 percent, 0.8 above the year before. As manufacturing recovered and job expansion occurred in the nonmanufacturing sector, the rate dropped to 5.5 percent in May 1973, but in the following months of 1973 the rate was at or around the 6.0 percent mark. The high level of unemployment persisted into 1974 and in May it was 0.8 above the same month in 1973. During the first half of 1974, joblessness averaged 6.2 percent of the civilian labor force, compared with 6.0 percent during the first six months of 1973.

The unemployment picture in Ventura County during June 1974 compared favorably with the State but not with the nation. Locally, the jobless rate was 6.4 percent which was below the State rate of 7.5 percent, but above the 5.2 percent level nationwide.

The civilian labor force in Ventura County rose 12.4 percent over a four-year period (1970 thru 1973). During this span the expansion in labor force kept reasonable pace with the growth in civilian population, which rose by approximately 13 percent.

The local labor market outlook for the remainder of 1974 is somewhat pessimistic. Growth in employment is expected to slow further as business expansion is dulled by high interest rates and inflationary pressures on the local economy increase. In addition, a further slowdown in population growth will limit expansion in many industries. Employment is expected to show an expansion of about 4 percent in 1974, substantially less than the growth rate of 5.3 percent experienced between 1972 and 1973.

Wage and salary employment is expected to grow during the latter half of 1974 but at a somewhat lower rate than that exhibited during the first six months of the year. Seasonal employment gains are looked for in retail trade and services but at a somewhat lower level than a year ago. Manufacturing employment will slow further during the remainder of 1974 while high interest rates are expected to limit growth in construction. Government employment is expected to expand primarily at the state and local level.

The employment outlook in construction for the remainder of 1974 is not favorable. A trade dispute involving carpenters, laborers, pipefitters, plumbers, and cement masons in Southern California occurred in early July and in Ventura County an estimated 1600 persons were out of work. Continuing high interest rates and the decline in population growth are factors expected to effect building activity in Ventura County in the coming months.

The continuing growth in civilian labor force is likely to push unemployment up with the rate rising to an estimated 6.8 percent in the last half of 1974 due to a construction strike in July and a general slowdown of the economy.

The deepwater general cargo port located at Port Hueneme is contributing to the growth of Ventura County's economy. The replacement of two obsolete berths with three deepwater berths, the building of facilities for handling bulk fuel, and, for the first time, a business development activity, add up to an increase of future traffic.

In addition to the county's present tourist attractions, the 500,00 acre Los Padres National Forest provides potential recreational facilities which could help proliferate job opportunities in the trade and services sectors. These industries are expected to provide the major upward impetus in employment during the next several years.

Labor Market Trends

Much of Santa Barbara County is mountainous terrain. Approximately 40 percent of the total land area is either farmed or cultivated and another 44 percent is taken up by the Los Padres National Forest in the eastern part of the county.

Table II-109

EMPLOYMENT BY INDUSTRY
SANTA BARBARA COUNTY
(Thousands)

Industry	July 1971	July 1972	July 1973
Total civilian employment	100.9	103.2	105.8
Nonagricultural wage & salary workers	81.8	84.0	86.6
Mining	1.0	.9	.9
Construction	3.7	3.7	3.6
Manufacturing	9.8	10.0	10.5
Food products	1.6	1.5	1.7
Paper, printing & publishing	.8	.9	.9
Petroleum & chemicals	.3	.4	.4
Primary & fabricated metals	.3	.5	.5
Nonelectrical & electrical machinery	2.7	2.8	3.0
Transportation equipment	.2	.2	.2
Other manufacturing	3.9	3.7	3.8
Trans., communication & utilities	3.5	3.4	3.3
Wholesale & retail trade	19.0	19.7	30.3
Finance, insurance & real estate	3.3	3.6	3.7
Service	20.7	21.8	23.0
Government (a)	20.8	20.9	21.3
Other nonagricultural employment (b)	12.3	12.5	12.5
Agriculture	6.8	6.7	6.7

(a) Includes all civilian employees of Federal, State, and local governments, regardless of the activity in which the employees are engaged.

(b) Includes employers, own-account workers, unpaid family workers, and domestic servants.

Source: State of California, Employment Development Department

Over 50 percent of the county labor force is located adjacent to the major centers of Santa Barbara City and the Goleta Valley in the southern part of the county. The industrial mix in that area is concentrated in services, government, trade, manufacturing and agriculture, in that order.

The number of nonagricultural wage and salary jobs in Santa Barbara County rose by 6.1 percent in 1973 with most major industries contributing to the gain. The largest absolute gain occurred in the services industry as tourism continued to be a viable factor in the sector. Employment in the retail trade division also rose significantly in 1973 and the increase was mainly due to the expansion of existing facilities and an increase in the level of consumer expenditures.

Services, the largest employing division in Santa Barbara County, employed an average of 23,000 workers in 1973 reflecting an 8 percent increase over 1972. Tourism in the area spurred employment in hotels and lodging places during the summer months. Medical and health services employment, which comprises more than one-fifth of the total payrolls in the services division, showed consistent growth throughout all of 1973. The largest component in services continues to be the business services group which is comprised mainly of scientific and technical research and development firms.

The government division, the second largest employing category in Santa Barbara County, had an average work force of 22,200 in 1973. This count is only 300 or 1.4 percent higher than the comparable figure reported in 1972 with local government payrolls accounting for the entire net gain.

Trade employment, averaging 21,300 in 1973, was 1,600 or 8.1 percent higher than the 19,700 recorded in the previous year. Annual average gains occurred in both the wholesale and retail divisions. Most retail jobs are found in eating and drinking establishments, automotive dealers and service stations, and general merchandise stores.

The number of workers reported on manufacturing payrolls in Santa Barbara County firms rose by 1,100 or 10.4 percent between 1972 and 1973 with net gains occurring entirely in the durable goods group. In the nondurables classification, modest annual growth in food processing was equally offset by scattered losses in most other groups. In durables, more than half the annual advance occurred in the manufacture of electrical and scientific equipment while partial losses were evident in ordnance.

The annual average unemployment rate in 1973 at 4.8 percent was well below the previous year's level of 5.6 percent. The area's seasonally adjusted and unadjusted unemployment in 1973 ran well below the California rate but somewhat paralleled comparable rates for the United States. By September 1974 the unemployment rate had climbed to 5.7 percent, the highest to date for the year. The average unemployment averaged 5.2 for the first 9 months of the year which is slightly higher than for the same period in 1973 of 4.9 percent. This is attributed to a construction strike in July and to a general slowdown in the economy.

The southern portion of Santa Barbara County continues to a nationwide tourist attraction. Consequently, motels, hotels, restaurants, and related service industries are major sources of employment opportunities. The education component is the major factor in employment in the government sector, with the Santa Barbara Campus of the University of California being the largest employer in the county. Manufacturing is primarily considered to be of light variety, in direct response to the communities' concern that the southern portion of the county not be despoiled by heavy industry. Therefore, volume jobs usually connected with manufacturing are not found in this area, but are restricted to assembly of electronic/electrical components and related operations.

The northern part of Santa Barbara County has been in a state of transition between rural and urban. A large percentage of the employment in the area, especially in the city of Santa Maria, is dependent upon agriculture, although manufacturing and service industries have played an increasing role in the total structure of employment over the past ten years. Vandenberg Air Force Base played a large part in the expansion of the area.

3. Agriculture - California's Leading Industry

California has a land area of 100.2 million acres and is the 3rd largest state in the United States ranking just behind Alaska and Texas. Approximately 36.2 million acres was utilized for farmland in 1973, which is better than 1/3 of the area of the state. On this farmland California farmers produced 9 percent of the national gross cash receipts from farming in 1973. This production was realised from 63,000 farms or 2 percent of the Nation's total. The average California farm was estimated at 575 acres in 1973 and valued at \$277,000 including buildings. Nationally, the average farm size in 1973 was 383 acres and valued at \$90,960 also including buildings.

California is the number one agricultural state in the U. S. In 1973, it led the nation in cash farm receipts for the 26th consecutive year, reaching a new landmark in California history of 7.5 billion dollars. This is 2 billion or 36 percent above the 5.5 billion record high established a year earlier (Table II-110). The 1973 gain in cash receipts was largely attributable to sharply higher prices, although there was increased production for several major crops.

One often overlooked fact about the California economy is that agriculture is the state's leading industry. During 1973 California outpaced Iowa, the nation's number two farm state, by \$750 million. Despite urban pressures that threaten farming in many parts of the state, acreage devoted to crops increased to 8.5 million acres from 8.1 in 1972. The state leads the nation in the production of 46 individual farm products, ranging from alfalfa seed and almonds to

Table II-110

Southern California Coastal Counties
Agricultural Receipts
and Major Crops
1971, 1972, 1973

County	Cash Farm Receipts			Annual Percent Change		Most Important Crops and Values 1973 (Millions)			
	1973	1972	1971	72-73	72-71				
Ventura	277,793,100	220,328,400	200,401,100	26.1	9.9	Fruits & Nuts	144.8	Vegetables	75.9
San Diego	219,342,100	167,510,700	153,092,630	30.9	9.4	Eggs	49.7	Tomatoes	29.5
Los Angeles	136,802,100	120,667,630	123,205,040	13.4	-2.1	Nursery		Livestock	
Santa Barbara	152,215,806	115,140,543	108,725,570	32.2	5.9	Stock	50.7	& Poultry	48.8
Orange	131,104,900	97,563,200	96,977,900	34.4	0.6	Cattle			
						& Calves	29.1	Lettuce	19.8
						Nurs. Stock & cut flowers	45.6	Eggs	18.0
Totals \$	917,258,006	721,286,343	672,402,240	27.5 <u>1/</u>	5.9 <u>1/</u>				
Total Calif. <u>2/</u>	7.5 billion	5.5 billion	5.0 billion	36.4	10.0	Cattle & Calves	1,315.5	Milk & Cream	693.8
So. Calif. Cash Farm Receipts as a Percent of the State	12.2	13.1	13.6						

1/ Weighed by county receipts2/ Rounded totals for state

Source: U. S. Dept. of Agriculture, Departments of Agriculture of the Respective Counties.

tomatoes and walnuts, and including such diverse items as eggs, carrots, melons, olives and lettuce (Table II-111). The state accounts for more than 90 percent of the nation's production of almonds, apricots, artichokes, broccoli, dates, figs, garlic, grapes, nectarines, olives, persimmons, pomegranates, prunes, safflower, clover seed and walnuts.

The state's harvested farm production in 1973 was the largest on record at 44.3 million tons, up 1 percent from the previous 1972 high of 43.9 million tons. Increased aggregate production for vegetables and fruits and nuts more than offset a lower output from field crops. Increased production of significant magnitudes includes processing tomatoes (7 percent), peaches (9 percent), grapes (72 percent), walnuts (45 percent) and prunes (164 percent) while lower outputs were recorded for sugarbeets (29 percent) and all hay (4 percent).

California's "Top Twenty" crop and livestock commodities accounted for over 80 percent of the state's gross farm income in 1973. Cattle and calves and dairy products continue to dominate the livestock industry, while grapes, cotton, hay and tomatoes are the most important crops. In dollar value of marketings cattle sales brought in over \$1,316 million followed by milk and cream (\$694 million), grapes (\$609 million) and cotton lint (\$395 million). (See Table II-112).

California's agriculture is considered one of the most diversified in the world, with no single crop dominating the state's farm economy. This is illustrated by the fact that most crops individually account for less than 3 percent of the state's total gross farm income. California also leads the nation by a wide margin in the production of fruits and vegetables.

Table II-111

Crop and livestock commodities in which California leads the Nation

Alfalfa seed	Carrots	Ladino clover seed	Peaches	Strawberries
Almonds	Cauliflower	Lemons	Pears	Spinach
Apricots	Celery	Lettuce	Peppers, bell	Safflower
Artichokes	Cut flowers	Lima beans	Peppers, chili	Sugarbeets
Asparagus	Dates	Misc. melons	Persimmons	Tomatoes
Avocados	Eggs	Nectarines	Plums	Walnuts
Blackeye beans	Figs	Nursery stock	Pomegranates	
Broccoli	Flower seeds	Olives	Potted plants	
Brussels sprouts	Garlic	Onions	Prunes	
Cantaloupes	Grapes	Oriental vegetables	Rabbits	

Source: U. S. D. A., California Crop and Livestock Reporting Service, California Agriculture 1973

Table II-112
California
Ranking and Value
20 leading farm products,
1972-73

Farm product	Commodity ranking		Value <u>1/</u>		Percentage of state total	
	1972	1973	1972	1973	1972	1973
	Number		1,000 dollars		Percent	
Cattle & calves	1	1	1,049,169	1,315,549	19.1	17.6
Milk & cream	2	2	608,082	693,802	11.1	9.3
Grapes	3	3	364,958	609,422	6.6	8.1
Cotton, lint & seed	4	4	306,841	483,029	5.6	6.5
Hay	5	5	281,486	385,385	5.1	5.1
Eggs, chicken	7	6	202,461	323,629	3.7	4.3
Tomatoes	6	7	258,741	308,721	4.7	4.1
Rice	11	8	128,868	258,659	2.3	3.5
Lettuce	8	9	183,287	257,655	3.3	3.4
Nursery products	9	10	170,021	242,900	3.1	3.2
Almonds	14	11	98,125	192,960	1.8	2.6
Oranges	12	12	123,158	133,262	2.2	1.8
Turkeys	16	13	73,048	123,987	1.3	1.7
Potatoes	19	14	67,698	116,312	1.2	1.6
Sugarbeets	10	15	133,659	115,920	2.4	1.5
Barley	15	16	74,867	110,262	1.4	1.5
Cut flowers	13	17	105,641	106,000	1.9	1.4
Wheat	27	18	42,012	100,360	0.8	1.3
Walnuts	22	19	65,424	97,440	1.2	1.3
Prunes	28	20	41,195	95,613	0.8	1.3

1/ Based on value of quantity harvested for crops and on value of quantity marketed for livestock and poultry products.

Source: U. S. D. A. California Crop and Livestock Reporting Service, California Agriculture, 1973.

In 1972 the average value of farm land per acre in Southern California was the highest in the state in 4 out of 8 categories including non-irrigated cropland, pastureland, rangeland and irrigated orchards. Since then non-irrigated farmland in the central coast area has appreciated at a rapid pace relegating Southern California's non-irrigated farmland to second place in all categories in terms of value (Table II-113. A possible exception would be irrigated orchards for which current average values were not available.

In 1973 approximately 12.2 percent of total cash receipts for all farm products sold were produced in the Southern California Coastal counties. This compares with 13.1 percent in 1972. Total cash receipts were up sharply for the area in 1973 reflecting a 27.5 percent rise. Although this appears to be a very large increase it is still 9 percentage points below the state increase of approximately 36 percent (Table II-110. These increases primarily reflect sharply higher prices for a wide variety of products rather than increased production.

The south coast counties rank in 1973 according to their total cash farm receipts were Ventura, San Diego, Santa Barbara, Los Angeles and Orange.

Ventura County not only ranked first in value of production but also claimed agriculture as the number one industry in the county. The major crops are fruits and nuts (lemons, oranges, walnuts) which accounted for over 1/2 of the gross income attributable to agriculture. Income received for this one major crop group was up 38 percent in 1973 and was mainly responsible for the county's large increase in agricultural receipts. Vegetables were also a primary source of income but total receipts were

Table II-113

California
Average value of farmland per acre
by district and land use
March 1973

District	Irrigated <u>1/</u>				Nonirrigated		
	Truck and Vegetables	Intensive field crops <u>2/</u>	Intensive field crops <u>3/</u>	Pasture	Crop-	Pasture	Range-
<u>Dollars</u>							
Northern California <u>4/</u>	805	520	440	575	330	315	200
Central Coast	2,250	1,590	1,095	1,025	930	760	400
Sacramento Valley	1,035	910	770	600	435	340	225
San Joaquin Valley	1,215	1,005	880	695	430	330	205
Southern California	1,480	1,170	920	960	685	525	320
State	1,550	1,035	865	695	580	440	250

1/ Orchard and grove values not available for 1973.

2/ Includes land used for cotton, sugarbeets, rice, etc.

3/ Includes land used for barley, beans, corn and sorghum.

4/ Excluding Sacramento Valley.

Source: U. S. D. A. California Crop & Livestock Reporting Service, California Agriculture 1973.

up only slightly compared to a year earlier. Approximately 3 out of 10 dollars in total agricultural income in the Southern California coastal counties was produced in Ventura County in 1973.

In San Diego County, the major commodities were eggs and tomatoes followed by avocados and milk. Income from these four commodities represented almost 60 percent of the agricultural income to the county. Egg production values almost doubled but this was offset by soaring feed costs. It was noted that farmland acreage in the county was up almost 5000 acres or 9 percent compared to the 1972 level.

Agriculture continues to be the leading industry in Santa Barbara County as cash receipts rose 32 percent from approximately 115 million dollars in 1972 to 152 million in 1973 (Table II-110. Increased receipts from cattle and calves and the lettuce crop were mainly responsible for the added income. Receipts from cattle and calves were up almost 50 percent to \$29,129,819 while the lettuce crop receipts increased from approximately 8 1/2 million dollars to almost 20 million. Increased lettuce acreage as well as unit price were significant factors. Los Angeles County farm and agriculture receipts were up 13.4 percent to \$136,802,100 in 1973. Record wholesale nursery crop sales (up 10 percent) led all plant crop groups showing increases.

The second largest agriculture income group was livestock and poultry which reflected a 13 percent increase in receipts. Consumer boycotts, high feed prices, relocation of dairy herds outside of the county and other negative effects were offset by slightly larger beef cattle inventories and higher prices received.

These two groups, nursery stock and livestock/poultry, account for over 70 percent of the county's agricultural income.

The 13.2 percent increase in agricultural sales in Los Angeles County was significant in light of the fact that in 1972 sales were off 2.1 percent compared to a year earlier. At the same time the increase was so small in comparison to the other 4 counties in the study area that Los Angeles County dropped from third to fourth place in value of production of sales and was passed by Santa Barbara County in 1973.

Although agriculture sales in Orange County were the smallest of the South Coast Counties, the percent increase (32.2) was the largest compared to a year earlier. Favorable weather combined with much better prices received in 1973 helped make it the best year on record. Approximately 500 acres of truck crops acreage was lost to other uses (3.6 percent) but production in this area was still up 8 percent. The two major commodities in 1973 were nursery stock/cut flowers and eggs. Combined income from these commodities was up over 50 percent compared to a year earlier.

Agriculture in California is important not only in supplying food to the Nation, but also for many other reasons. It has created many jobs in commerce and industry, and contributes directly or indirectly almost \$19 billion a year to the state's economy. The state's farm production accounts for 1/2 of the total tonnage shipped by trucks and approximately 1/2 of the value of water borne exports from California ports. Lastly, there are nearly 3,000 manufacturing plants for processing food and kindred products in the state.

4. Income Characteristics

The California coastal zone is the most highly developed portion of the state. Within this area is found the bulk of the state's population and the major portion of its income. The intensive urbanization in and around the Los Angeles, San Diego and San Francisco areas is an expression of some of the advantages which the coastal zone enjoys over other areas of the state.

In an important respect, the comparative advantages of the urban complexes around the coast is strongly associated with their position as transportation modes and dependence on harbors and shipping. A number of economic activities are drawn to the ports, including warehouses, insurance companies and industry.

While it is true that many of the industries that form the basis of the California economy do not use the ports extensively to ship their products (e.g., aircraft, electronics industries), the income generated nevertheless creates an enormous demand for goods which must be met.

Other industries which are drawn to the coast are canneries, petroleum refineries, defense installations, etc. As a result of this concentration, service industries and others which are market oriented will also tend to locate near the coast.

a. Personal Income

Personal income, of which the main component is wages and salaries, accounts for approximately 80 percent of gross state product. Employment trends is one of the significant factors affecting the growth of personal income. The large movement of wage earners into Southern California in the 1950's and early 1960's had direct impact on

total personal income in Southern California. Since then, migration from other regions of the country has slowed dramatically. This resulted in Southern California's income growth becoming more closely aligned with the growth rate of the nation.

Total personal income for the five Southern California coastal counties is estimated at \$59.3 million for 1973. This is 9.8 percent above 1972 and approximates the personal income growth rate of California as a whole (Table II-115).

Within Southern California a major factor affecting personal income gains has been county-to-county population and labor shifts. It is important to note in this respect that county personal income data measures income earned by residents of that county regardless of which county the income was generated in. Thus county business trends may not parallel personal income trends exactly.

In 1960, Los Angeles County's income accounted for almost 78 percent of the five-county total (Table II-115, but by 1973 this figure had dropped to 70 percent. The estimate for 1973 is \$41.3 million up 9.2 percent from a year earlier. Los Angeles County income consistently registers the greatest numerical increases because of its size in relation to other counties, but has virtually the slowest rate of growth due mainly to out-migration.

Personal income for Orange County is the fastest growing, not only in Southern California, but in the state. Estimates indicate that a larger number of the people moving out of Los Angeles County are resettling in Orange County to the extent that the county population is also the fastest growing in the state. With 1973 personal income

Table II-115

TOTAL PERSONAL INCOME, SOUTHERN CALIFORNIA, CALIFORNIA AND THE NATION
(\$000,000)

		1960	1965	1970	1971	1972	1973	Percent Change 71-72	Percent Change 72-73
Los Angeles		18,071.5	24,288.0	34,282.9	35,300.6	37,786.0	41,278.0	7.0	9.2
Orange		1,702.0	3,373.1	5,968.3	6,291.2	6,971.0	7,766.0	0.8	11.4
San Diego		2,590.2	3,273.8	5,662.4	5,925.0	6,535.0	7,267.0	10.3	11.2
Ventura		473.5	758.0	1,220.8	1,314.8	1,437.0	1,596.0	9.3	11.1
Santa Barbara		445.1	746.3	1,098.6	1,160.4	1,264.0	1,389.0	9.0	9.9
Southern California									
	Total	23,282.3	32,439.2	48,233.0	49,992.0	53,993.0	59,296.0	8.0	9.8
California									
	Total	42,980.0	60,234.0	89,312.0	94,412.0	102,100.0	112,100.0	8.1	9.8
United States									
	Total	400,953.0	538,893.0	808,290.0	863,515.0	939,161.0	1,033,200.0	8.8	10.0

Source: Security Pacific Bank, California Department of Finance, Williams Research Associates, U.S. Department of Commerce.

of almost \$7.8 million, this is about 11.4 percent above the previous year. Orange County also has the highest estimated median income in the study area of \$14,471 for 1973 (Table II-115). Ventura County has also absorbed part of the population outflow of Los Angeles County and with an estimated 11.1 percent growth in personal income in 1973, is exhibiting rapid growth.

San Diego County reflected an extended 11.2 percent increase in personal income in 1973, tourism and recreation industry has been expanding as well as the trade and services industries. Among all the state's metropolitan areas only San Diego County benefitted from the military base cutbacks in 1973, as the county was the focal point of base consolidations. Santa Barbara County registered almost a 10 percent increase in personal income in 1973 compared to a 9% increase a year earlier. Construction was much weaker during 1973, but retail sales were up sharply.

b. Gross National Product

The most comprehensive measure of activity within any economy is gross national product (GNP) defined as the final market value, in current prices, of all goods produced and services performed. In terms of GNP, the United States ranks ahead of all countries in the world. If the state of California's total production in 1972 was ranked with the ten largest countries in the world, it alone would have ranked seventh on the list (Table II-116).

The coastal zone counties from Santa Barbara south to the Mexican Border produce more than one-half of the state's total goods and services, which points up the significance of this area in broad terms.

TABLE II-116

GROSS NATIONAL PRODUCT OF THE WORLD'S
TEN LARGEST COUNTRIES, PLUS CALIFORNIA

1982 Rank	Countries	Current U.S. Dollars			10-year % In- crease '72/'82
		1962	1972	1982	
		(billions).....			
1.	U.S.	\$ 560	\$1,155	\$ 2,600	125%
2.	U.S.S.R.	247	560	1,400	150
3.	Japan	59	294	1,100	274
4.	West Germany ..	90	260	850	227
5.	France	75	202	700	247
6.	United Kingdom	80	154	400	160
7.	Italy	44	117	375	221
8.	Canada	40	103	325	215
	California	62	126	300	138
9.	China	67	120	275	129
10.	India	36	60	125	108
	Top ten countries' GNP % of total	\$1,298 74%	\$3,025 74%	\$ 8,150 74%	169%
	Rest of world's GNP % of total	452 26%	1,075 26%	2,850 26%	165%
	Total world GNP.	<u>\$1,750</u>	<u>\$4,100</u>	<u>\$11,000</u>	<u>168%</u>

Source: United California Bank, Research and Planning
Division, 1974 forecast.

After the economic doldrums of the 1970-71 recession, business activity in California picked up sharply. The 1971-73 growth pattern in California closely paralleled that for the United States. During the 1971-73 three year period, the gross national product advanced nearly 22 percent while California's gross state product climbed by nearly 21 percent.

c. Income by Source

Wages and salaries for California make up approximately two thirds of total personal income (Figure II-117). The group which receives the largest share of this are government workers followed by manufacturing, wholesale and retail trade workers, and those in the service industries.

d. Per Capita Income

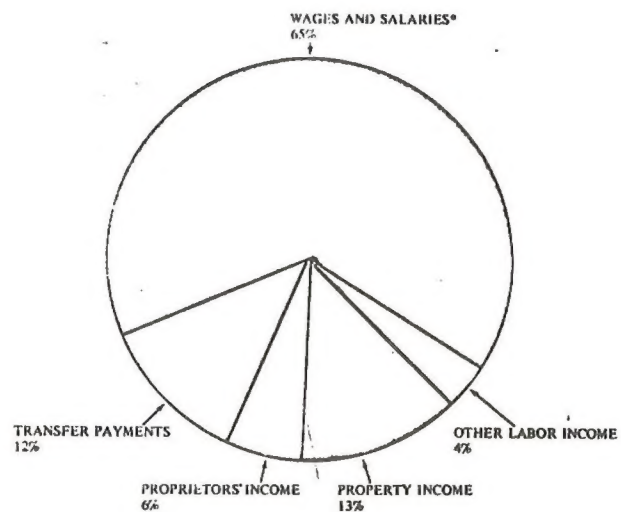
Per capita income in the five Southern California coastal counties is estimated at \$5,513 for 1973, 2 percent above the California and 12 percent above the U. S. per capita incomes. This area (Southern California) with its concentration of highly paid manufacturing wage earners has historically registered per capita income levels slightly higher than the rest of the state and considerably higher than the national average (Table II-118). More important is that Southern Californians are experiencing a rising standard of living by virtue of earnings growth after adjusting for inflation. Since the beginning of the last decade, per capita income has risen by an average of 5.2 percent annually while consumer prices have risen by 2.9 percent.

e. Median Family Income

Median income could be defined as the middle income in an array from the lowest to the highest. The median family income in

FIGURE II-117

TOTAL PERSONAL INCOME,
SOUTHERN CALIFORNIA
BY SOURCE, 1973



*Excludes employee contributions for social insurance, paid by wage and salary workers.
Source: Security Pacific Bank

TABLE II-118

PER CAPITA INCOME AND CONSUMER PRICE INDEX, SOUTHERN CALIFORNIA
CALIFORNIA AND THE NATION

	Per Capita Income			Consumer* Price Index		C.P.I. Percent Change Year Ago	
	<u>So. Calif. /1</u>	<u>Calif.</u>	<u>U.S.</u>	<u>Los Angeles</u>	<u>U.S.</u>	<u>So. Calif.</u>	<u>Los Angeles</u>
1960	\$2,833	\$2,709	\$2,129	88.5	88.7	-	-
1965	3,367	3,258	2,773	95.7	94.5	3.5	2.1
1970	4,602	4,436	3,945	114.3	116.3	5.9	5.1
1971	4,713	4,652	4,171	118.5	121.3	3.6	3.7
1972	5,058	4,976	4,497	122.3	125.3	7.3	3.2
1973	5,513	5,405	4,911	129.4	132.7	8.9	5.8

*1967 = 100

Source: Security Pacific Bank, California Department of Finance, U.S. Department of Commerce
Bureau of Labor Statistics

/1 Includes Los Angeles, San Diego, Ventura, Orange, Santa Barbara Counties only.

Southern California coastal counties ranges from a low of \$12,533 in San Diego County to a high of \$14,471 in Orange County (Table II-119). Compared to the median family of the United States, all counties in the South Coast area are above this average from as little as 3 percent to a maximum of 19 percent. In comparison to the median family income for the state as a whole, the southern coastal counties do not come out as well. Los Angeles and Orange Counties exceed the state average while Santa Barbara, San Diego and Ventura fall below. Indications point to a continuation of this trend in 1974.

TABLE II-119

MEDIAN FAMILY INCOME, SOUTHERN CALIFORNIA, CALIFORNIA AND THE NATION

<u>Counties</u>	<u>1970</u>	<u>Actual</u>	<u>1972</u>	<u>Estimated</u>	<u>Forecast</u>	<u>Numerical Change</u>		<u>Percent Change</u>	
		<u>1971</u>		<u>1973</u>	<u>1974</u>	<u>'72/'73</u>	<u>'73/'74</u>	<u>'72/'73</u>	<u>'73/'74</u>
Los Angeles	11,390	11,718	12,654	14,095	15,290	1,441	1,195	11.4	8.5
San Diego	10,507	10,807	11,506	12,533	13,260	1,027	727	8.9	5.8
Ventura	11,423	11,563	12,233	13,466	14,395	1,233	929	10.1	6.9
Santa Barbara . . .	10,931	11,152	11,880	13,098	13,895	1,218	797	10.3	6.1
Orange	\$12,620	\$12,642	\$13,271	\$14,471	\$15,310	\$1,200	\$ 839	9.0%	5.8%
California	<u>\$11,156</u>	<u>\$11,472</u>	<u>\$12,289</u>	<u>\$13,527</u>	<u>\$14,485</u>	<u>\$1,238</u>	<u>\$ 958</u>	<u>10.1%</u>	<u>7.1%</u>
United States . . .	<u>\$ 9,867</u>	<u>\$10,285</u>	<u>\$11,116</u>	<u>\$12,150</u>	<u>\$13,000</u>	<u>\$1,034</u>	<u>\$ 850</u>	<u>9.3%</u>	<u>7.0%</u>

Source: United California Bank, Research and Planning Division 1974 forecast

J. Future Environment Without the Proposal

It is important that the future environment of Southern California be examined in the event that the proposal does not occur.

Since the Southern California Bight area is highly urbanized it is expected that the existing form and structure will continue with an increase in population growth. Some governmental planning efforts are being directed towards a controlled population growth concept which will slow the rate of growth that has been recorded since the 1940's. No matter what the official policy is, growth will continue both in population increase and in the expansion of urban land uses.

An associated growth will occur also in the recreational demands of the people. As a result, the pressures for water-oriented facilities will increase along most of the coast. It is expected that use of the Channel Islands will be sought after as an additional area for recreation. The use of boating and ocean types of activities will also be in greater demand in the future.

Since continuing population growth and activities will occur, the resultant environmental costs will also be present. The continuing efforts by government towards the goal of eliminating air and water pollution will result in some gains as technology and public awareness advances.

The reliance on the ocean for food sources will become more important in the future as current sources become inadequate to meet

demand. It is anticipated that efforts towards increasing offshore food production will be increased and that new ocean sources will be examined for possible use.

Public awareness towards ecology and the environment will increase, especially in the area of the marine biota. As a result, greater efforts will be directed towards the protection of the ocean and all its species. In following this course, use and activities on or near the ocean will receive greater scrutiny than what is given at the present.

Human habits may be changed in the future because of higher costs for all segments of the economy. One probable change is that more people will spend vacations closer to home and will utilize local facilities. By doing so, the recreational facilities will receive greater use and the demand for new facilities will increase.

State OCS production has declined from a high of 89,061,000 BBL of oil in 1969 to a low of 70,582,582 in 1973. This trend of decreasing production can be expected to continue unless new development is undertaken in State submerged lands. If OCS Sale #35 does not take place, pressure to increase State production will increase and probably would result in additional near shore development to augment supply. If demand continues to increase, State OCS production would be environmentally more dangerous than Federal OCS production, since the State OCS operations would be closer to shore. Alaskan crude has been advocated by the Coastal Commission as a possible alternative

to additional Federal OCS development. But at a production rate of 2 million bbls a day Alaska's North Slope reserves of 9.5 billion bbl's would only last for 13 years.

However, with the arrival of 1,200,000 bbls of Alaskan crude in 1978 a surplus of 150,000 to 600,000 bbls of oil could develop on the west coast. This surplus is expected to be transported to the Midwest via pipeline from the Los Angeles or Long Beach harbor. It is projected that 20 tankers with a combined deadweight tonnage of 1,390,000 dwt and a turnaround time of 14.5 to 15.5 days will be required to transport the crude from Alaska to the Los Angeles area. This would result in added ship traffic of one or two tankers a day being docked and unloaded in the Los Angeles area. Foreign imports via tankers from Indonesia are expected to continue. Indonesian oil has a lower sulphur content than domestic crude and would therefore, be required for processing and for direct burning as boiler fuels.

Three LNG facilities are now under consideration to handle Alaskan LNG. The proposed sites for these facilities are Point Conception, Oxnard and Los Angeles harbor. Alternative sites under consideration are Port Hueneme, El Segundo, Carlsbad and Border Field on the Mexican border.

Each of these facilities would be able to receive LNG for a base load vaporization rate of 4 billion cubic feet of natural gas (4,000 mmcf/d) and would require 34 acres of land. (Detailed environmental analysis concerning proposed LNG facilities can be found in the Dames and Moore publication for the Western LNG Terminal Company before the Federal Power Commission Docket No. CP75-83).

The Los Angeles or Long Beach harbors would require a minimum of dredging in order to increase harbor depth to accommodate large oil tankers. One of these two ports will be used to offload Alaskan crude for pipeline transport to the mid-west.

Other proposed projects which are presently under consideration include a proposed refinery and marine terminal at Carlsbad, and possible additional nuclear power plants. The proposed refinery and marine terminal would again necessitate some dredging with the additional impacts of increased air pollution, and land disruption for facility siting and pipeline right-of-way to transport oil eastward. The nuclear plants would require certain acreage for the facility and could cause thermal pollution of nearby waters from the cooling water discharge and could create radioactive waste products which have a high pollution and safety potential.

SUMMARY

Without development of the Federal OCS there may be increased pressure to further develop the state OCS lands along the nearshore coastal area. This would result in considerably more visual aesthetic impact than development of Federal areas which lie further offshore. In the event of an oil spill the nearness of structures in state waters would have the effect of increasing the impacts as the travel and weathering time of the oil would be considerable less than in Federal areas resulting in more toxic elements remaining in the oil as it reached shore.

The ever increasing demand for oil would probably also lead to increased imports of foreign oil which would result in more tanker

and barge traffic and the need for deepwater ports to handle the huge supertankers that have been proposed for use by shipping companies. New port facilities would also be needed by liquified natural gas (LNG) tankers. One such proposal which is currently being reviewed by the Federal Power Commission involves three LNG terminals proposed by Western LNG Terminal Company for location at Point Conception, Oxnard, and Los Angeles harbor. These terminals will again increase tanker traffic and pose significant safety problems. Additional nuclear plants and refinery projects would also create pollution problems for the Southern California coastal area.

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